

**SYSTEMS AND METHODS FOR ESTABLISHING
SHOOTING TRAJECTORIES AND
MANUFACTURING SUPPORT APPARATUS FOR
PYROTECHNIC DEVICES TO PRODUCE AND
PROJECT PREDEFINED AND PRECISE
PATTERNS IN THE AIR**

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The present research relates to designing a system for an array of *pyrotechnic* projectiles that combined in a single or sequenced event can produce shapes, letters or any pattern in the sky.

The origin of the research dates back to 1994 during the Commonwealth Games in Victoria, BC, Canada, when we first attempted to shoot up in the air the pattern of a Thunderbird.

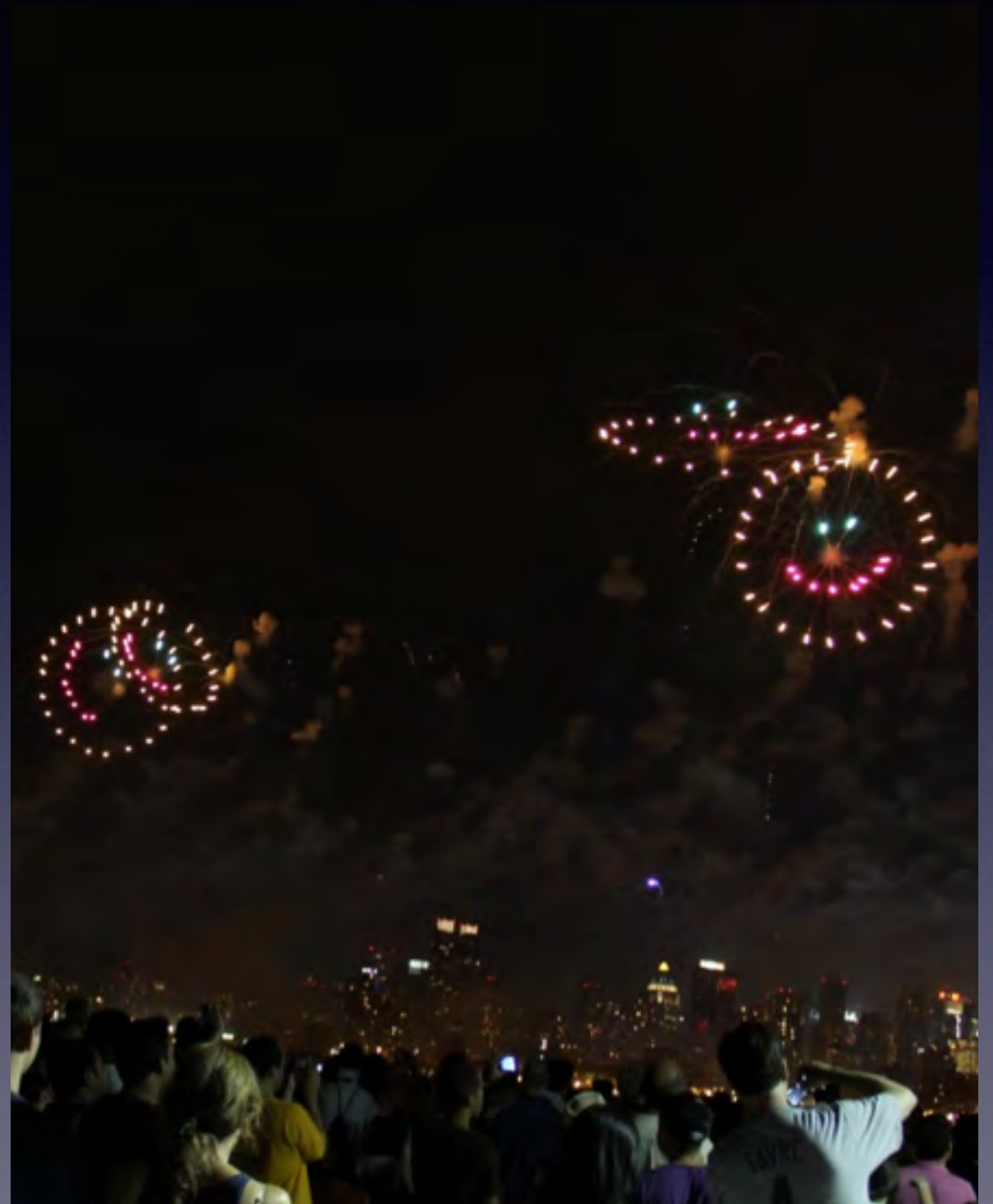
In 2003 an algorithm was developed as part of the Visual Show Director™ software FX Generator™. From drawings or plotted patterns with set size and altitude, the algorithm will translate them into shooting angles from one point of origin on the ground, producing a pattern in the air.

The problem...

Fireworks traditionally have been producing patterns from shells with various distributions of the stars in their cores.

These patterns cannot be obtained consistently in fixed three-dimensional orientations.

This is due to the random rotation of the burst of the charges up in the sky.



The Existing Solutions...

Mapping Canvas Focus

For several years various individuals, companies and organizations have been researching and developing methods to produce pyrotechnic graphics.

There are also a few patents for different methods as mentioned in the Bibliography section of this paper.

U.S. Patent

May 6, 1997

Sheet 1 of 16

5,627,338

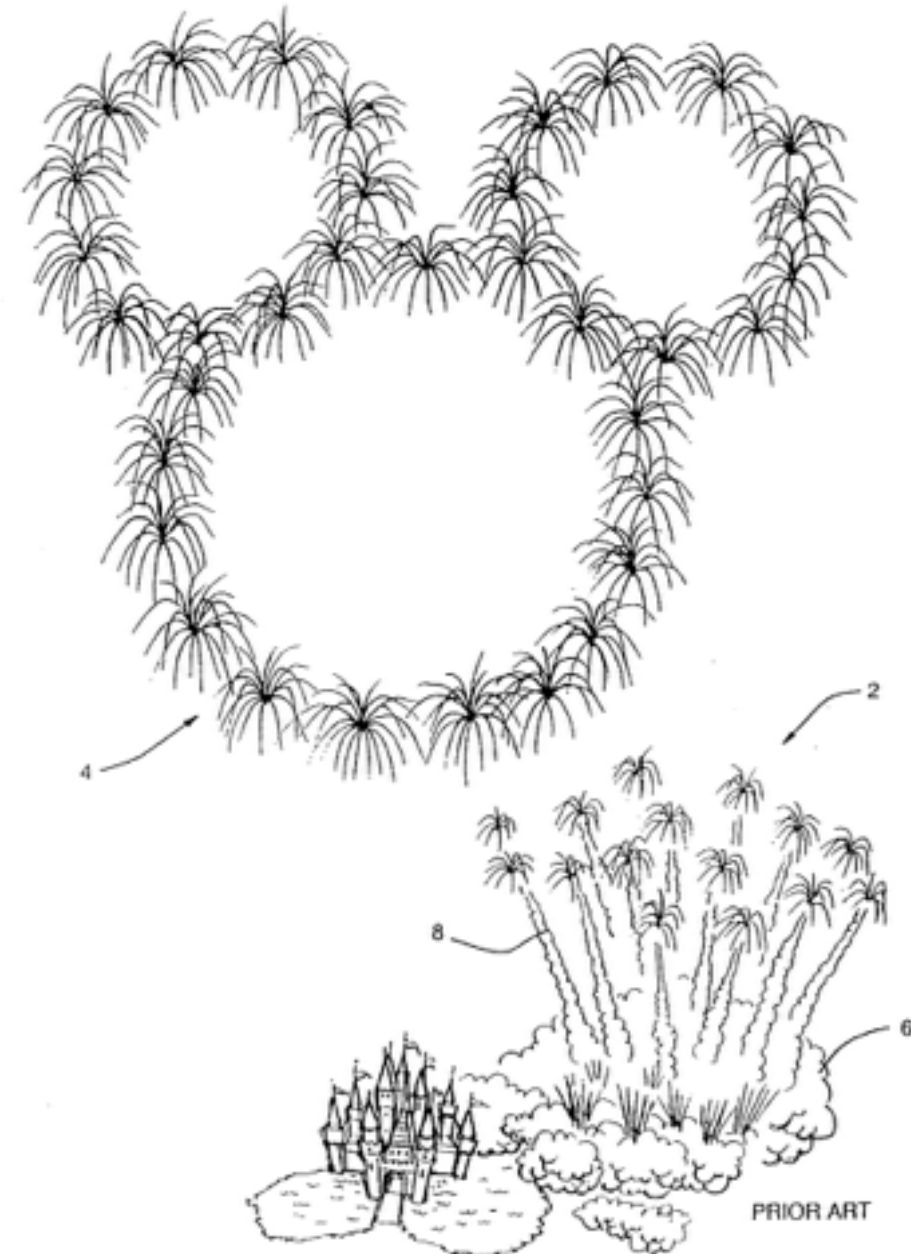


FIG. 1

Solution

Mapping

An alignment of mortars or tubes as large as the pattern that appears in the sky, launching stars or shells.

The pattern is created in a parallel plane of the same size as the distribution on the ground.

The pattern appears in the air at the altitude that the pyrotechnic comets or shells reach.

This type of pattern production is best perceived from an aerial perspective such as a helicopter.

From the ground it will be only seen from directly underneath and if it is not too large or low.



Solution

Canvas

A pattern that displays in a vertical plane in the sky.

It is necessary to control the altitude of each individual shell. This requires higher technology with electronic timers in the shells with a millisecond resolution or a combination of altitude control with an air launch system.

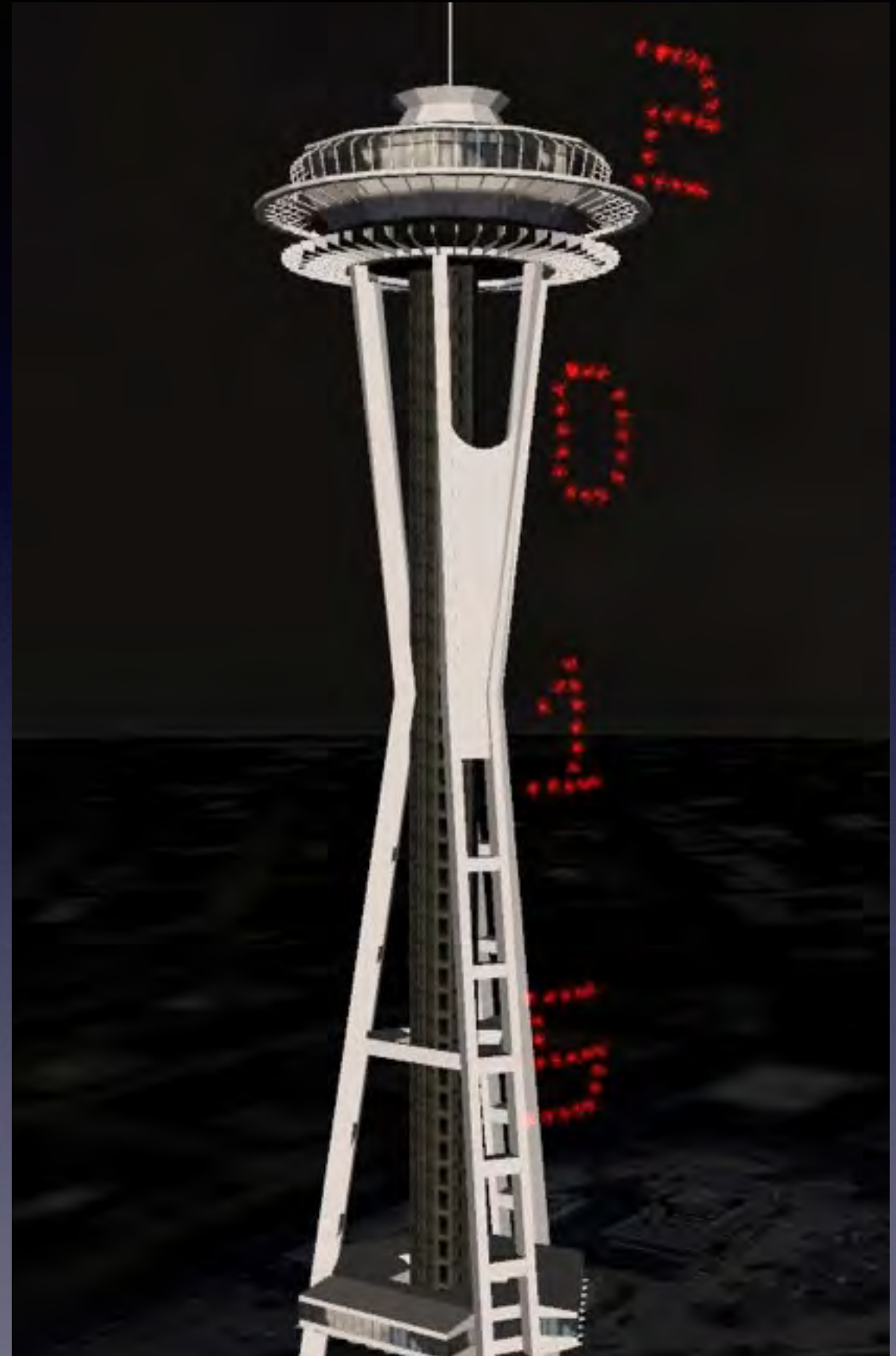


Solution

Focus

The present research treats the creation of patterns from a single focal projection point.

Patterns created from a single focal point are simple when launching conic or simple linear shapes. When more complex artwork has to be achieved calculations must be done using specialized software tools.

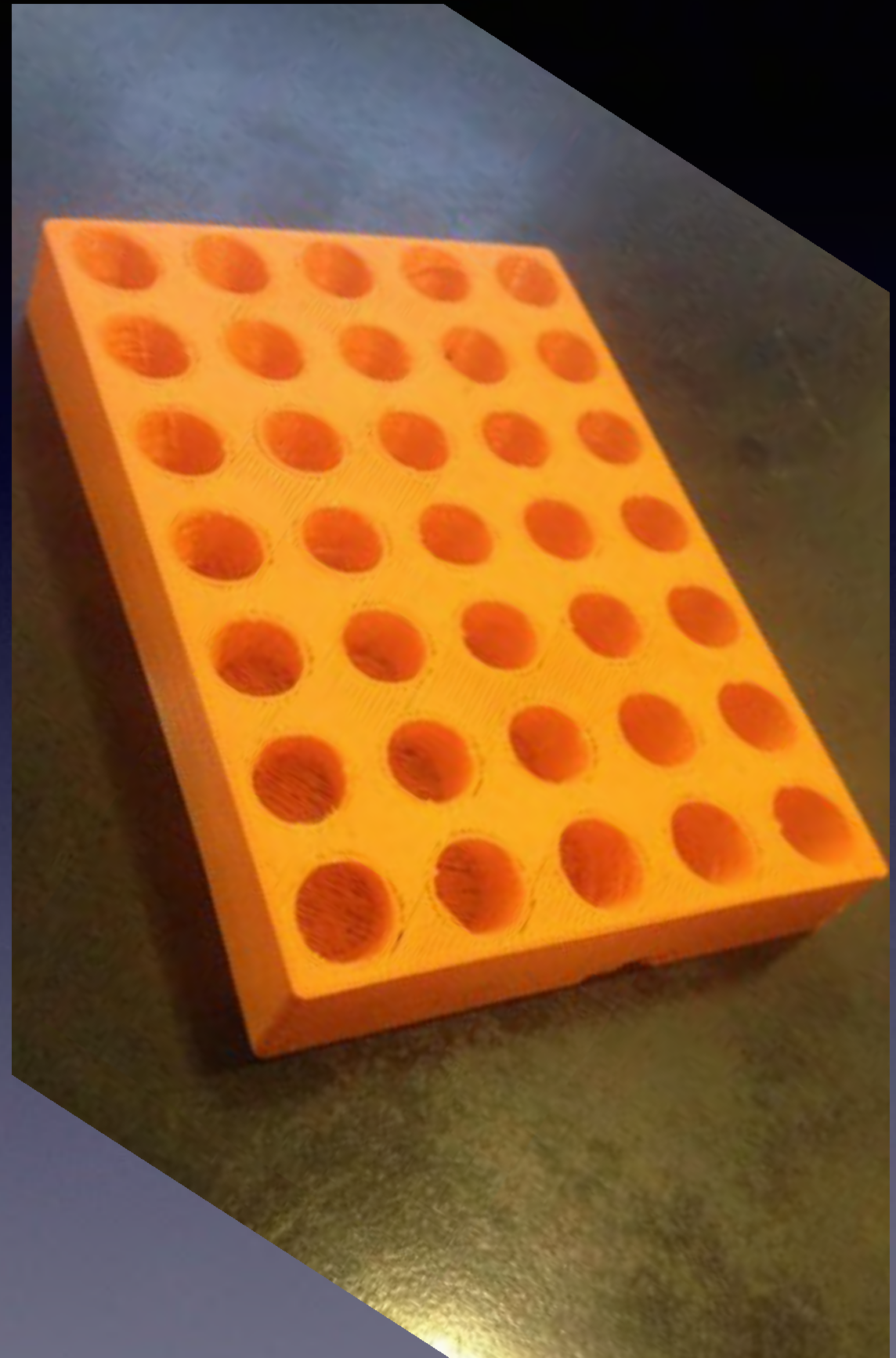


Factors

Prop Precision

Pyrotechnic supports for the pyrotechnic tubes must be exact and preferably made using one of the following systems:

1. Multiple axis CNC drilled holes with the pan and tilt angles provided by the program.
2. 3D printed block
3. Two plan plywood layers with laser cut holes



3D Printed 5x7 shots Universal pattern support

Factors

Pyro Precision

It is essential for the all of these methods that the pyrotechnic devices are precise and consistent in duration and altitude .

The orientation of the shots towards the audience and other viewing points is also an important factor for readability of the patterns.



Factors

Pyro Types

Different types of fireworks can be used to produce the patterns, provided that they are consistent in altitude and duration.

Comets or meteors will produce single dotted patterns.

Small Shells or Mines made of many fine particles or stars with reduced spacing will produce a more or less continuous pattern outline.



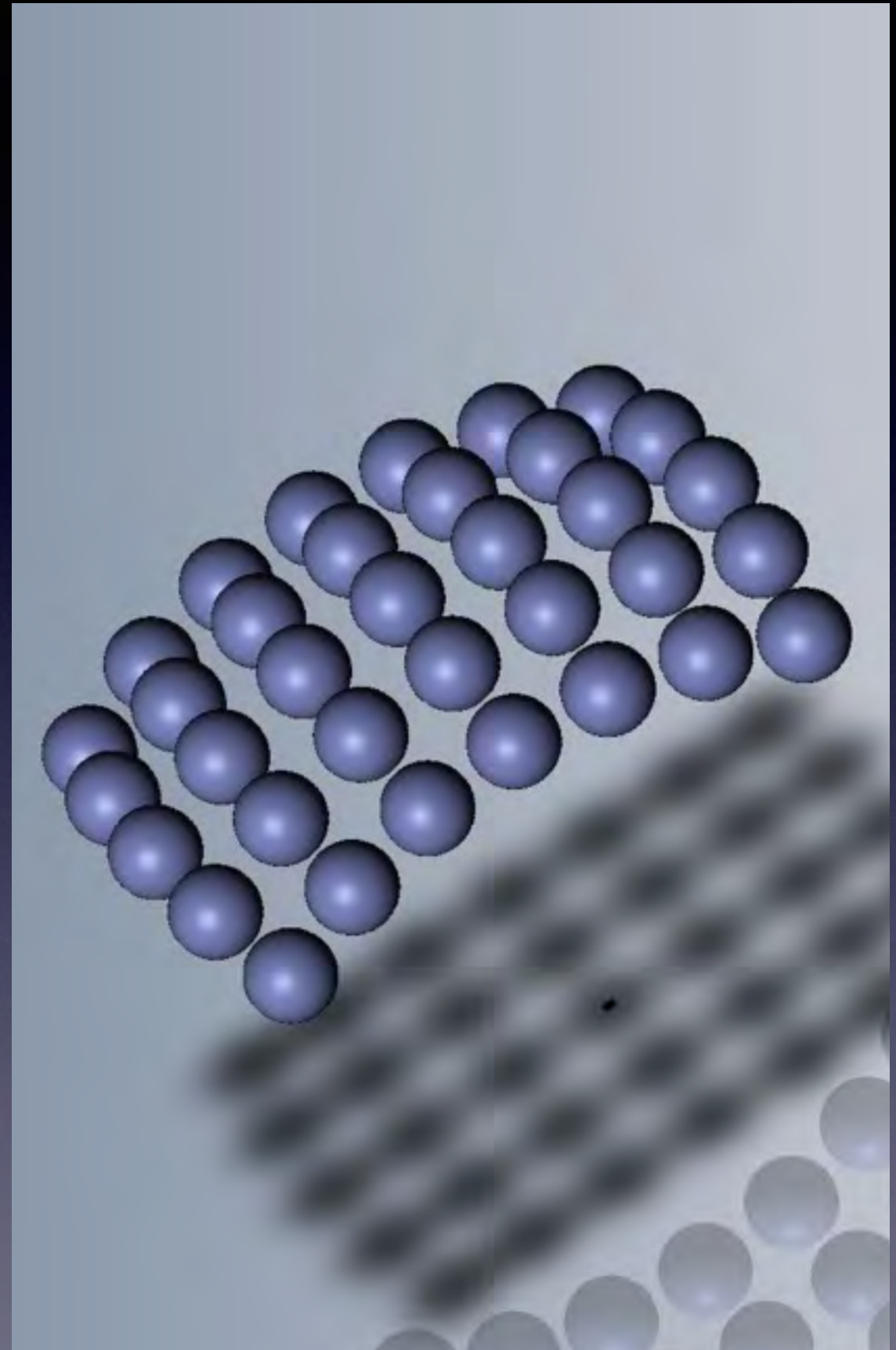
Factors

Deformation

The creation of patterns from a single focal point will produce a pattern in the air in a spherical cap related to the angles apertures and distances.

It must be taken into account that there will be deformation if the pattern is too wide for short trajectories.

The orientation of the prop must be adjusted for optimal public viewing points by rehearsing with the simulation software.



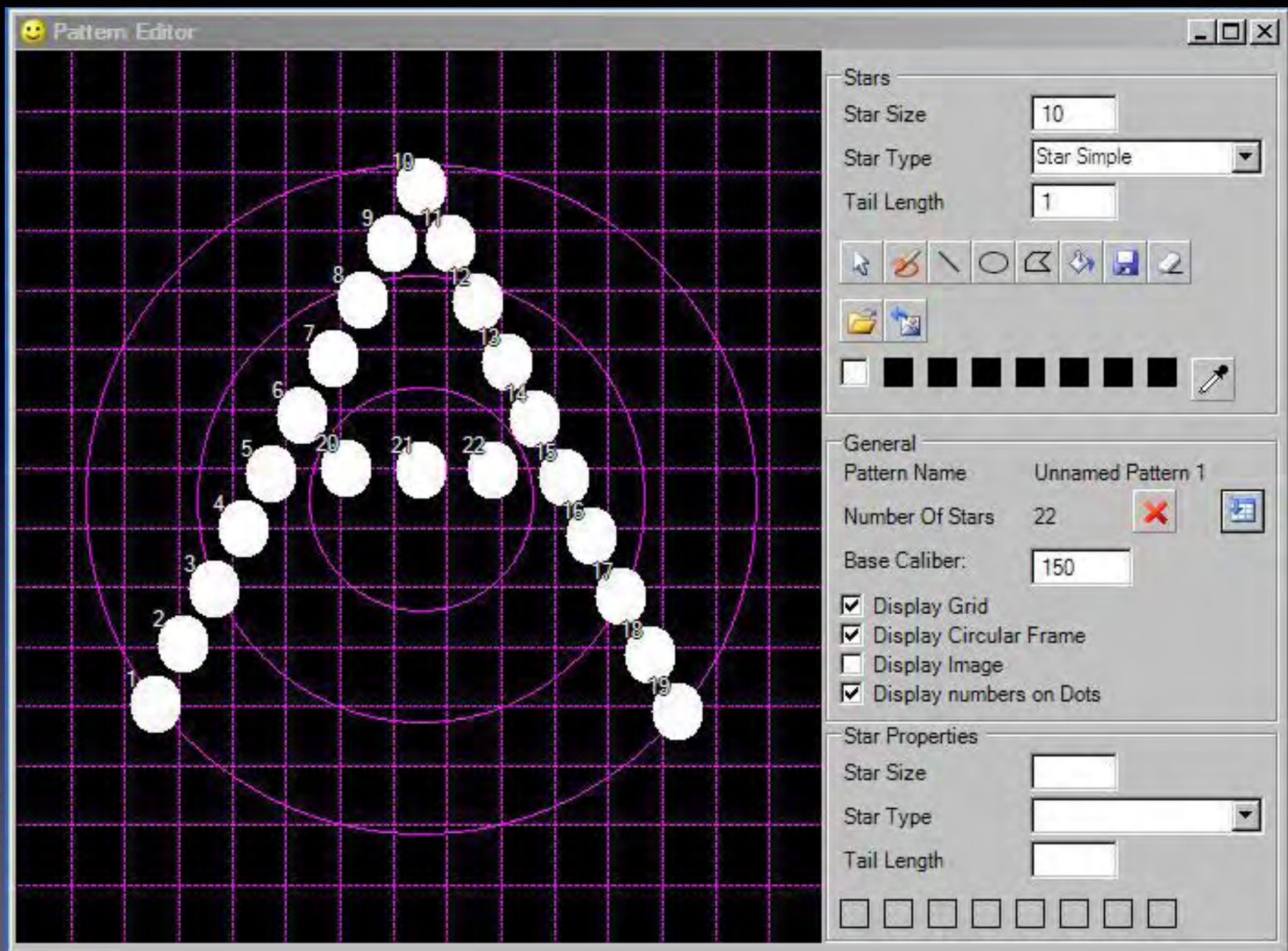
DESIGN METHOD

Software

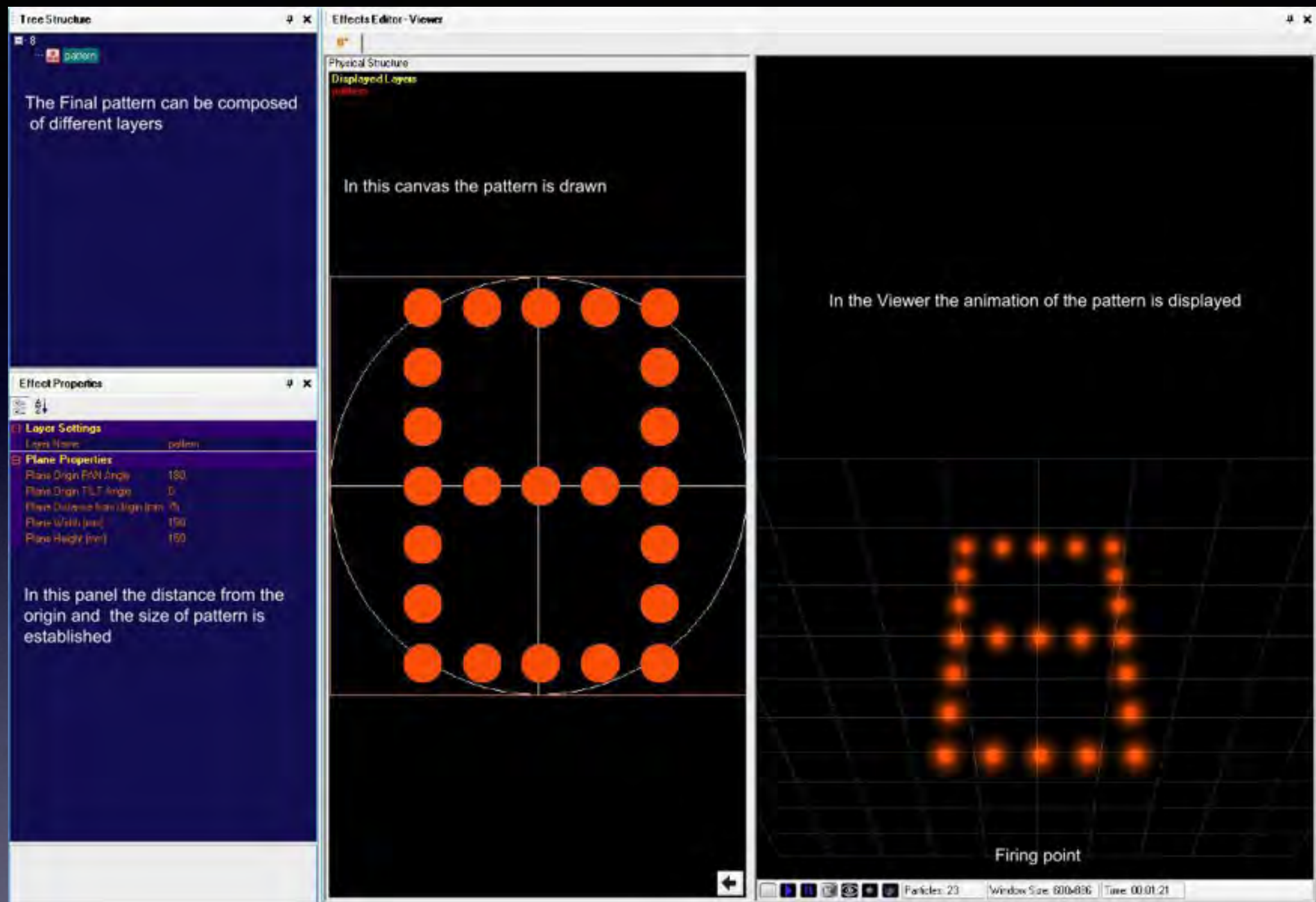
The computer program (Visual Show Director – FxGenerator) is used to draw patterns, letters, numbers or scan pictures. It produces dot patterns that are sized for the required width and height. These are translated into a list of shooting angles (pan and tilt) from the ground, for each projectile, in order to produce the pattern drawn in the program.

The program simulates the effects and is a tool for virtual rehearsal as well as precise product production and firing.





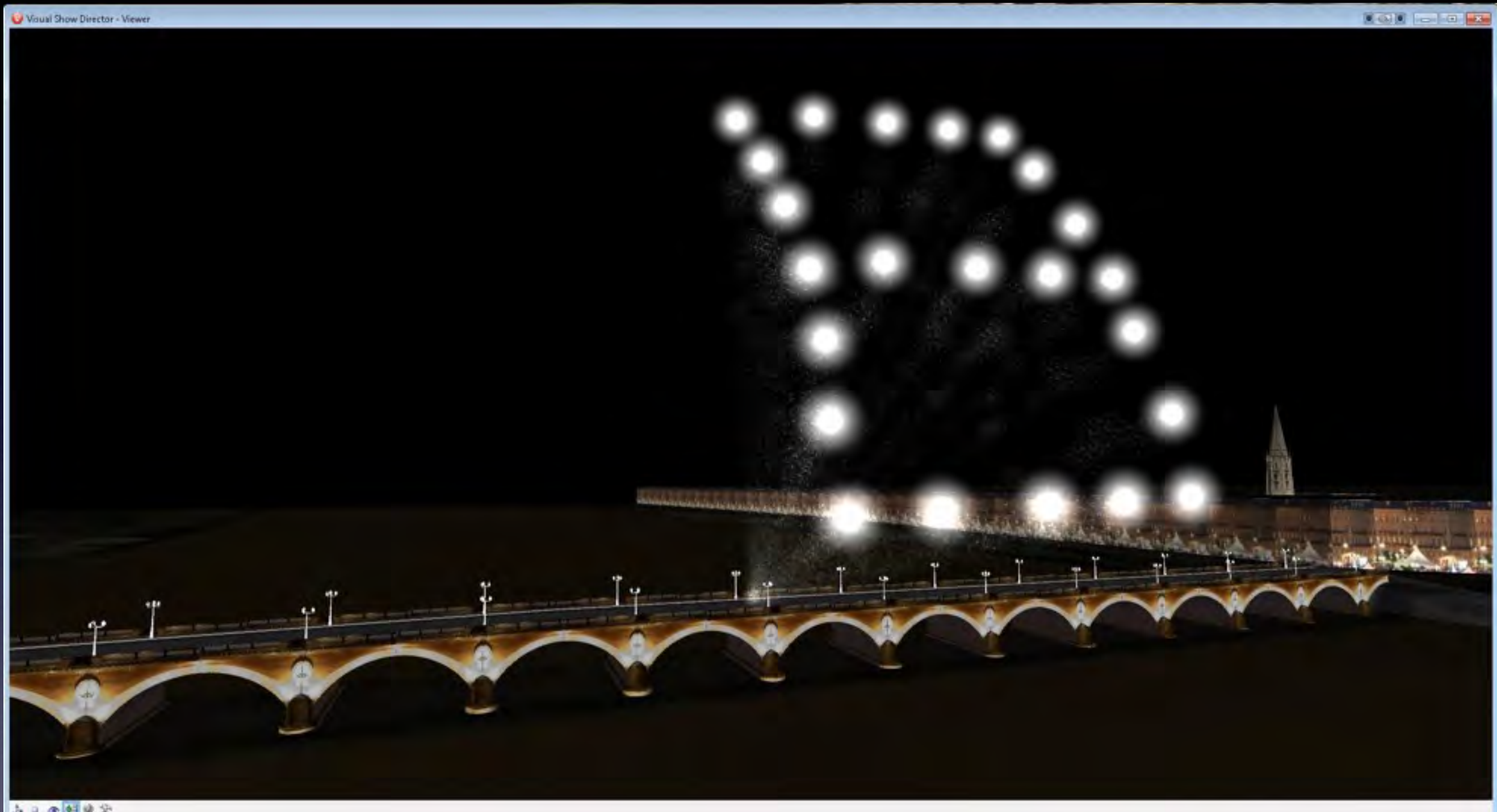
Pattern Editor in early version of VisualShowDirector FX-Generator (2002)



Pattern Editor in later version of VisualShowDirector 8 -
FX-Generator 4D (2008)

Script Manager - [A]														
	CUE	HH	MM	SS	FF	POS	QTY	CAL	TYPE	DUR	Effect Description	PAN	TILT	REF
	1	00	00	00	00	Ground 1	1	100	LETTER -A	04:00	SILVER BURST	012	86	
	1	00	00	00	00	Ground 1	1	100	LETTER -A	04:00	SILVER BURST	022	85	
	1	00	00	00	00	Ground 1	1	100	LETTER -A	04:00	SILVER BURST	029	84	
	1	00	00	00	00	Ground 1	1	100	LETTER -A	04:00	SILVER BURST	029	88	
	1	00	00	00	00	Ground 1	1	100	LETTER -A	04:00	SILVER BURST	035	83	
	1	00	00	00	00	Ground 1	1	100	LETTER -A	04:00	SILVER BURST	039	82	
	1	00	00	00	00	Ground 1	1	100	LETTER -A	04:00	SILVER BURST	042	81	
	1	00	00	00	00	Ground 1	1	100	LETTER -A	04:00	SILVER BURST	044	80	
	1	00	00	00	00	Ground 1	1	100	LETTER -A	04:00	SILVER BURST	061	88	
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	1	00	00	00	00	Ground 1	1	100	LETTER -A	04:00	SILVER BURST	359	86	
	*													

Script produced with Pan and Tilt Angles for each shot



Number 8 above the Pont Vieux in Bordeaux (Simulation)



Prop installed by PyroSpectaculars in the Space Needle with number 2 filled with Next FX mines in the Universal support.



Test shot of Number 2 at Next FX factory



State of the Art and Future

VSD FX Generator software is developed to assist in the complete pattern making and firing preparation process

- To imagine the patterns and experiment creativity with shapes and compositions
- To obtain firing angles for the supports manufacturing
- To rehearse pyrotechnic effects of the patterns compositions and make adjustments for manufacturing
- To evaluate the best orientations and timings for the public perception in a real three dimensional environment

Development in progress includes

- Automatic prop design “machine ready” with a *SolidWorks* plug-in
- Programming of electronic timers and sequencing based on milliseconds pre-fire times
- Universal “PyroGraphics” support with totally adjustable caliber sizes and angles

CONCLUSION

- Today's Technology provides us formal elements with a greater graphic and artistic potential to compose and perform new expressions of sky art.
- CNC, 3D and Laser printing techniques, produce supports with exact and complex angles arrangements.
- Development of smokeless and high precision pyrotechnic products with electronic timers and controlled lift pressures.
- Designing with 3 Dimensional software to invent, rehearse and prepare for build.

These techniques are changing our industry. The ability to draw in the sky with pyrotechnics opens the future of fireworks to limitless design options, once thought impossible to produce and now a reality.

