

# SNOW Symmetric Nodal Origami World

## Preface

I first presented the ideas of Symmetric Nodal Origami at a BOS convention in 2005 and later to the Nederlands Origami Society. Following encouragement from David Lister and others I prepared a booklet in May 2006. I would like to thank Ian Harrison for his help and guidance in preparing this second edition. The pdf version was laid out by Nick Robinson.

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1. Origami by Computer. About 20 years ago Eric Kenneway in his ABC of Origami in the BOS magazine, referred to Computer Origami as follows: - "The first known attempt at designing Origami by computer took place in the United States in 1971. Arthur Appel, under the direction of the IBM World Trade Corporation's art director Bob Salpeter, programmed an IBM System 360 Model 91 computer to print out simple geometric configurations at the rate of more than one hundred a minute. Ninety percent were considered unsuccessful, but the remainder were folded on a large scale by Yokio Kono and displayed in the windows of the company's headquarters at United Nations Plaza, New York."

I was fascinated by this and tried out various ideas over the years. The 'success rate' of the IBM approach seemed to me unacceptably low and I wondered how this could be improved.

2. But why attempt this curious approach at all? Well I can only give some of my reasons; I like to try out new ideas and see where they lead. 'Classical' Origami is goal orientated. One sets out to fold an animal or a flower, for example, that is we have an end result in mind and try to find a way of folding it. Computer programmes such as those written by Robert Lang are aids in the achievement of a target image. The idea behind random folding is the opposite of this, we do not have a specific goal in mind, and we do not know what will emerge from the process.

3. After a great deal of experimentation I arrived at the idea of a grid of points or nodes. I could now use random methods to select a sequence of nodes in the grid and connect them, in order, by fold lines. There seemed to be two main difficulties to be tackled.

How to decide whether a fold between two nodes is to be a valley or mountain fold?

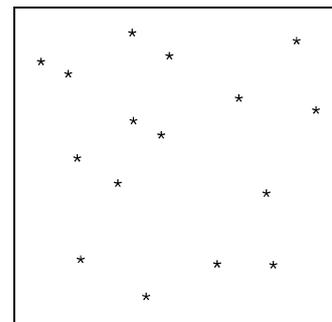
How can I ensure that the final configuration can be flattened?

I tried out many ideas to resolve these two difficulties. I explored the concept of randomly selecting a type of fold at a node, for example a reverse or sink, but it became apparent that this approach was far too complex to be practical, at least as a first step.

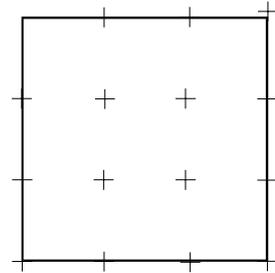
I then remembered what I had been taught about finding solutions to problems, always try the simplest ideas first and see if they work. The simplest way to tackle random folding seemed to me to be to select nodes and connect them by fold lines and see what happened when I tried to fold the result.

4. First of all I had to decide on a grid of nodes. The grid could consist of points located at random in the area of the paper. I rejected this approach because it made it difficult to reproduce the points and I felt that it was better to have a known regularity in the placement of the nodes or points.

On balance I decided to go for the simplest ideas and chose a regular pattern of nodes. There emerged a deeper reason for rejecting a random or haphazard placement of the nodes, symmetry depends on the nodes have a regular pattern.



I looked at a 2 x 2 and 3 x 3 pattern of points equally spaced horizontally and vertically but felt that this offered too few nodes to be rich enough for the selection process. I came to the idea of a 4 x 4 or a 5 x 5 pattern giving 16 or 25 nodes for random selection. The 5 x 5 pattern has the extra benefit of a central point. In the spirit of keeping things as simple as possible I decided to work with the 4 x 4 grid.



5. Using a computer programme I generated sets of random numbers from 1 to 16.

The approach I am using here does not depend on using a computer to generate the fold patterns, but as a convenience I used a simple pseudo random number generator programme.

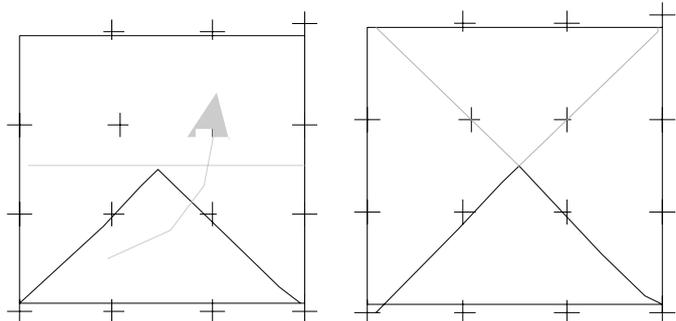
Simple random sampling means that for each selection the probability of selecting any of the 16 values remains the same i.e. 1/16. I now tried out the idea of selecting nodes using the random number tables and realised that I would almost always finish up with a complex asymmetric shape which would be extremely difficult to fold. The obvious point then occurred to me that all the classical bases and most Origami has symmetry in some way or other.

By using symmetry transforms I could generate structures which had repetition and variation. Why does this matter?

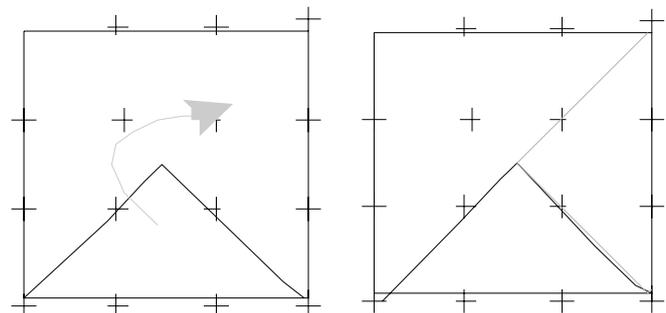
It has been known for a long time that we find great difficulty in dealing with events that have no discernible pattern yet we find mere repetition unattractive. This is particularly true in the arts where repetition with variation is a vital ingredient. In fact repetition with variation seems to be an element in the evolution of life itself and may indeed be part of our very nature. So now I found it necessary to investigate symmetry

6. I consulted my mathematics texts and found that there are three main symmetric operations: -

Reflection, has the effect of flipping an object or pattern, over a line inverting its image.

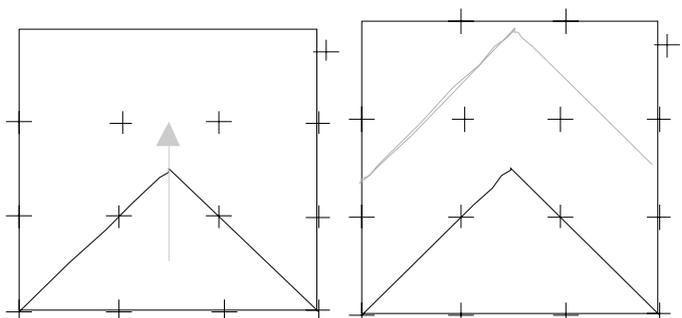


Rotation, the object or pattern is rotated around a point.



Translation, slides the object or pattern to a new position

First of all I looked at the Bird Base, perhaps the most important of the classical bases, to see how symmetry might apply. I was amazed at what I found. Using a bird base grid of 13 points I found that I could generate the bird



base from a simple 4 node pattern or as I began to call it, generator. By using a mirror symmetry and rotation I added to the generator and finished up with the bird base pattern. To flatten the result I needed to add a diagonal crease. But what about the folds themselves? I found that there seemed to be only one way to fold the pattern which used all of the fold lines and could be flattened and this was the bird base.

1. Generator

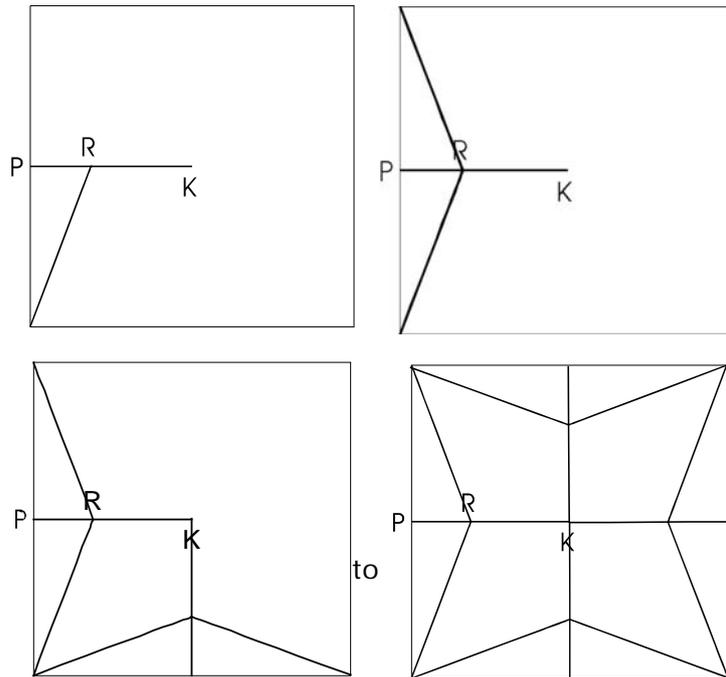
2. After reflecting horizontally

3. After reflecting diagonally

4. After reflecting diagonally again gives the Bird Base Pattern

Note: - The reflections are added in steps 2,3,and 4. It is possible to generate the bird base with a different sequence of symmetric operations

I found it surprising that so simple a generator could produce the bird base structure. I found a similar case for the fish base although the resulting configuration could be folded in two ways. It occurred me that I could define the nodes of the generator by reference to the original square corners and sides (using OIL for example) and thus the symmetry would create both the bird base grid and the fold lines of the base itself. (see section 12 for the use of OIL , Origami Instruction Language).



The results of the bird base research convinced me that I only needed simple generators and then use symmetry to create potentially interesting shapes.

7 At this point it occurred to me to return to the topic of how many shapes can be folded from a square of paper.

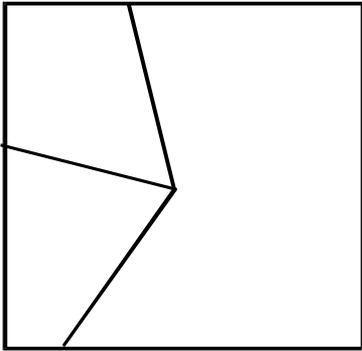
David Lister and I have looked at this before and it is easy to show that the number of shapes is either infinite or extremely large. But I have always worried about this because the differences between one shape and another may be so minute that they are practically identical. But if I use a grid of 16 or 25 points and only select a small number at random then employ symmetry this is likely to give me recognisably differentiated shapes. I looked at a 4 x4 grid and found that selecting 5 nodes at random with 8 variations of symmetry gave me at least 8 million different shapes If I selected 6 nodes in the same way then I had a potential of 50 million shapes. If I used a 5x5 grid and selected 5 points at random with symmetry then I found a possibility of 78 million shapes. There is evidently a lot of scope still for creators of Origami!

(Note: - It could be argued that the random process permits the selection of the same node and hence reduces the number selected for the generator. I have considered this but it is only of importance when the same node is selected in the following position. Thus for example, selecting 8-2-8-2-1, does impact the node count, but 8-8-2-2-1 could be argued as reducing the effective number of nodes selected to 3, rather than 5. It may be held that these are legitimate selections for the 5 nodes from the 16 possibilities, but in any case, excluding such cases has little impact on the numbers described above. According to my analysis only 160 selections would need to be deducted from the 1048576 shapes possible when selecting a sequence of 5 from 16. )

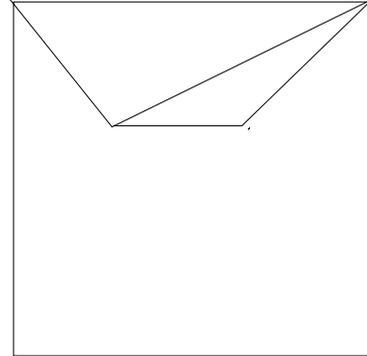
### 8 Puzzle Time.

While I was studying the patterns developed in the processes I have described, I considered the problem of selecting the valley and mountain folds for the fold lines connecting the nodes. Although in the end I decided that I would wait to see how the system worked on the simplest possible basis first of all.

I was led to the discovery that I may have found an Origami puzzle with a vast number of combinations. The idea is to solve how to flatten the fold lines given by the generator with symmetrical operations. All the fold lines must be folded and the challenge is to add as few additional folds as possible, which enable the result to be folded flat. The two diagrams below give an idea of the challenges posed.



Here it is possible to flatten on the fold lines with just one extra fold

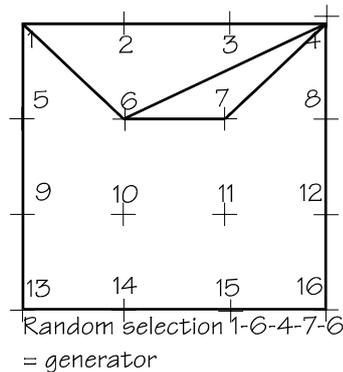


But how few extra folds will be needed in this example?

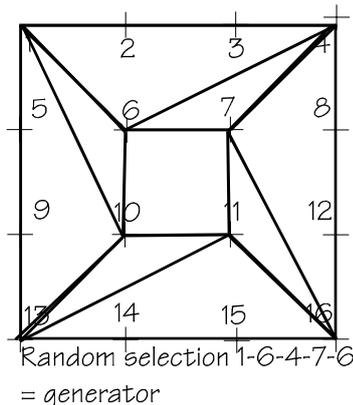
### 9 The Methods in Action

I used a 4 x 4 grid giving 16 points, (the 4 corners accounting for 4 of the points). The points are numbered from 1 to 16 row by row. I used a computer programme to select numbers from 1 to 16 (with replacement) in a pseudo random order, given an equal probability of any of the numbers being selected. Using a random starting point I then selected 5 consecutive numbers from those generated, yielding 1-6-4-7-6.

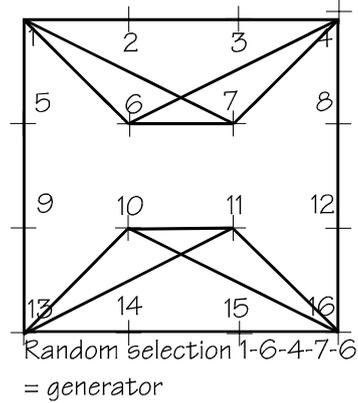
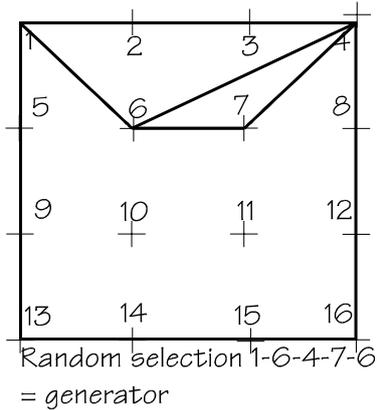
Connecting the numbers gives me my starting pattern or generator.



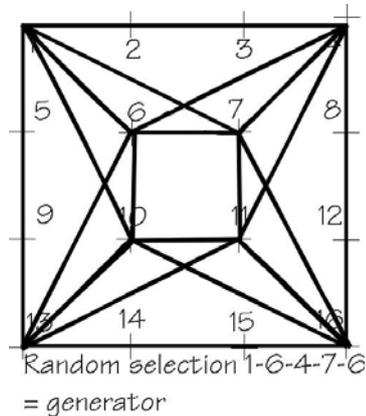
I now added 3 repetitions by rotated the generator through  $90^\circ$ ,  $180^\circ$ , and  $270^\circ$  to give this result. Notice that each rotation is added to pattern.



The previous example showed the effect of rotation, I will use the same generator and employ reflection (or mirror imaging)



The generator has first of all been reflected in the vertical axis and then the resultant configuration combined with its reflection in the horizontal axis to give the result shown here. These axis are located across the centre of the square. Combining this with a rotation through  $90^\circ$  gives the result shown here.

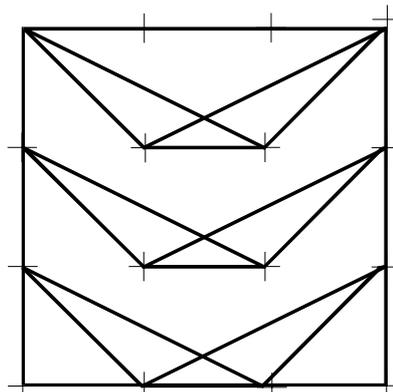
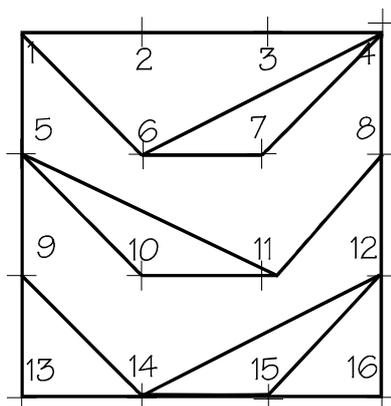
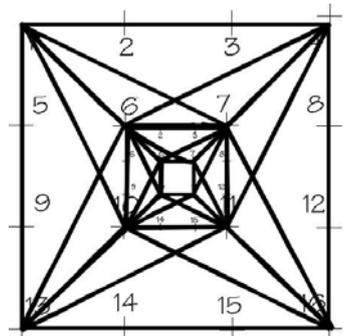


I can now illustrate a very powerful idea to add to the ones already shown and that is of scaling. The diagram on the right shows how the figure achieved in form 3 has now been scaled and added to the centre square.

Looking again at the idea of translation I tried out the following variations, (notice that the variations are added each time)

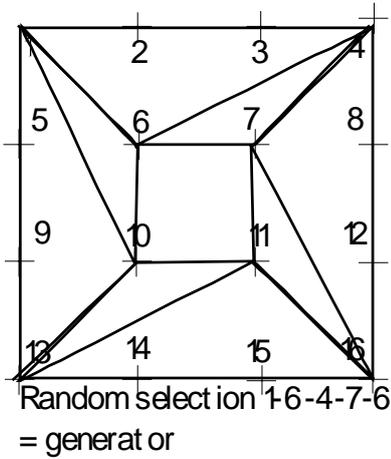
Here the original generating pattern is copied twice in a glide reflection.

This time a reflected (mirrored) version has been used.

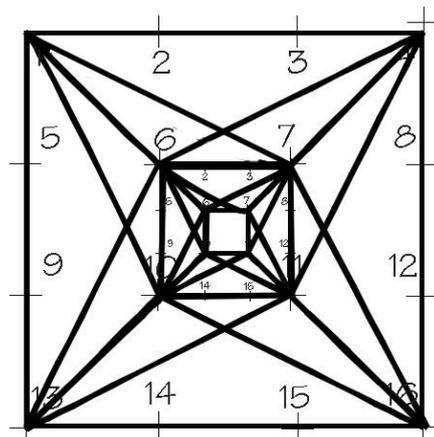
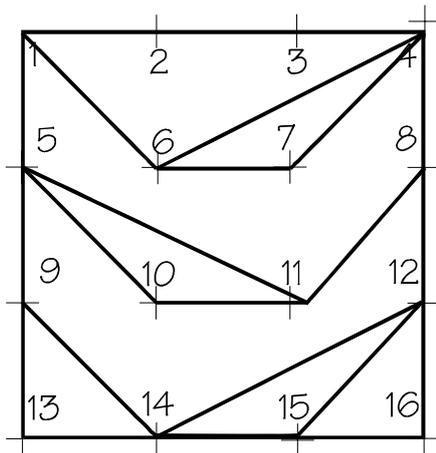


The time has come to look at the results of these symmetric variations of the one generator. I had to choose whether to make a valley or mountain fold on the lines, in practise this was not very difficult. I used alternate valley and mountain folds for adjacent lines and repeated this for all rotations. I found no cases which yielded a configuration for flattening the model, so I was necessarily dealing with a 3D in constructing the shapes.

Form 1

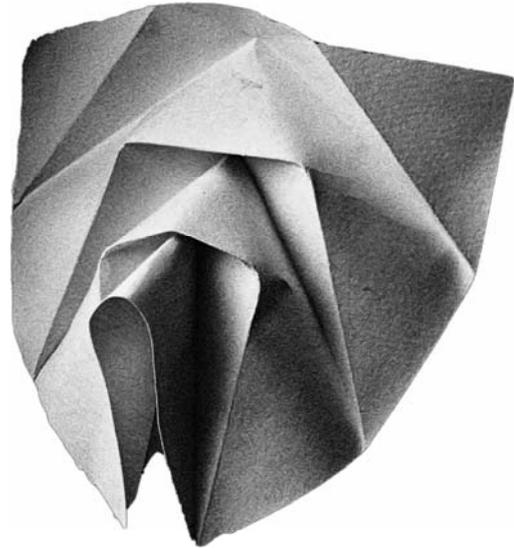
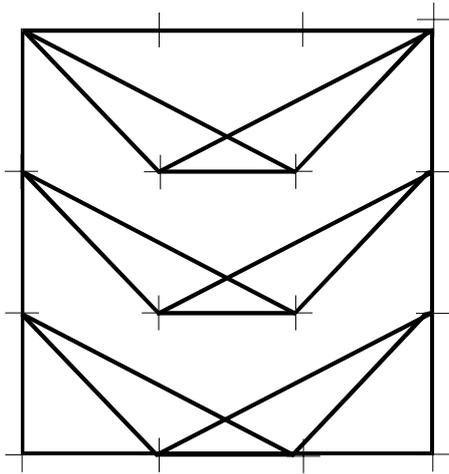


Form 5 Peaceful cat



Form 4 Sun Temple

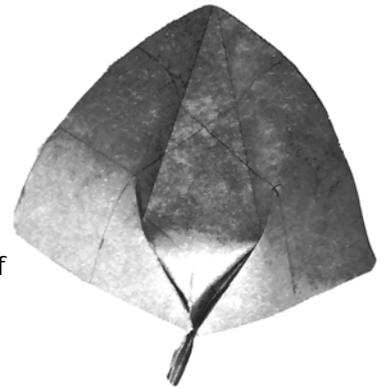
Form 6



It seemed to me remarkable that just one simple generator should yield such diverse images as a consequence of symmetric operations and folding. I think it as well at this point to make clear that using these symmetrical operations does not necessarily mean that the resultant configuration is mathematically symmetrical. For this to be true the resultant image must be identical with the original. For example a mirror image of the letter C is identical to the original but this is not true of the letter T.

10 More SNOW results

In my experiments with SNOW I arrived at more interesting shapes and I give a few examples with the generator and the symmetrical operations where I still know them. This rather pretty leaf is a result of a generator of  $G = 6-1-10-5-10$  in a 4 x 4 grid with a diagonal reflection.



I call this image Fox Head. It uses a 4 x 4 grid and  $G = 1-12-7-16-11$ , this is reflected vertically.

This is the same fold but upside down, it suggests to me a suppliant or 'at prayer'

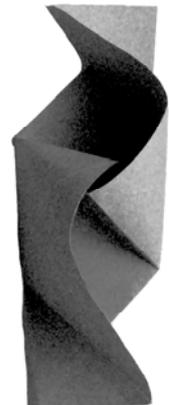


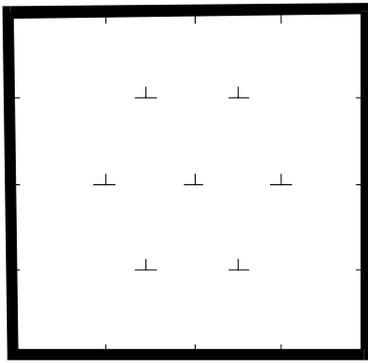
Now for some variations. This time I did not use random numbers but selected some interesting nodes which I thought might give new variations. Using a 4 x 4 grid I selected 1 -6 -8 -5 for  $G^1$  and  $G^2$  was  $G^1 +$  the mirror image of  $G^1$  in the vertical axis.



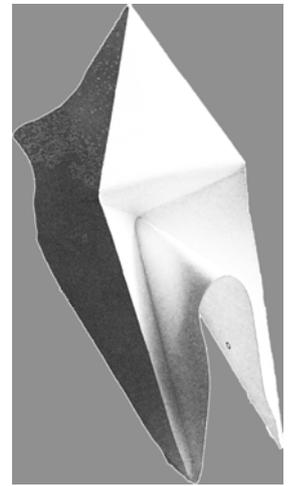
This was then translated 1 and 2 steps down on the grid. I called the result 'Geisha'. (right)

The version on the left was rotated about the centre and the base flattened. I call it John's Knot





In this model I went away from the simple 4 x 4 grid and tried a diamond layout. I used a random selection which gave me 6-1-10-5-16. This was then reflected horizontally. I called the result Easter Island Head.



## 11. Methods of creating SNOW shapes.

After a great deal of trial and error I have evolved a number of techniques :-

1. I use heavy paper at least 80 gsm , I have found water colour paper and pastel paper also work well. Since SNOW models usually involve induced curves I have found it important to use a heavier paper to achieve smooth shapes.
2. I have found that A4 paper which is 210 mm wide lends itself very easily to creating a 4 x 4 square grid since it gives the necessary three divisions each of 70 mm for the grid The nodes I consider to be numbered sequentially from 1 to 16 row by row. I have also used 5 x 5 grid with a 7.5 or 8.0 inch square.
3. I mark in pencil the grid node positions.
4. Using random number tables I select a sequence of three or more numbers from a random starting point. I pencil these in on my grid connecting them in the order given to me by the random sample I then decide on which symmetrical operations to use and mark these on the grid in pencil. I often try out a four-fold symmetry first but I have found that translation often suggests a way to achieve other interesting shapes. I have not yet experimented with diagonal symmetry; it may prove very interesting as it is a common basis for traditional Origami animals.
5. Using a fine pointed ball pen and a ruler I score the connections between the nodes I have marked in stage 4. The depth of scoring will depend on the type of paper being used , it needs to be heavy enough to make a sharp crease exactly where required without affecting the surface of the paper elsewhere.
6. I now begin to fold the shape. Usually I experiment with the long lines first using the same mountain or valley fold to keep the symmetry. Potential fold lines that meet at a node seem to require alternate valley and mountain folding. This part of SNOW is a case of intuition and experiment, there may be rules but if so I have not found them yet. In practise one set of fold lines can yield quite different shapes according to the way they are manipulated.
7. When I have a shape that I want to keep, I carefully decide how far the creases are going to pull the whole structure into interesting curved shapes. When I have done this I use paper tape or some form of enclosure to keep the model in the curved form that I want to achieve. I then spray with water just enough to dampen the paper and the dry it with a hair dryer, I keep repeating the process until I have obtained the shape I want. I am happy with this process since the curves are induced by the straight crease lines and not by sculptural moulding, these induced curves have a great beauty of their own, Another possibility is to use transparent paper which will reveal the hidden symmetries but I have not yet tried this.

## 12.- SNOW and a compact language for recording the structure.

The extraordinary compactness of SNOW arises because of the use of a numbered grid of nodes and simple symmetric operations. This can also be true for the classical bases of Origami. I will use the bird base to illustrate these principles.

It is first of all necessary to locate the node points which will be used by the generator. Fortunately I have already developed such a method in OIL, Origami Instruction Language (The BOS has a copy of the booklet)

The generator for the bird base requires four nodal points to be identified. In OIL these are defined as:-

$K = (1-4) = (2-3)$  (that is where a line from corners 1-4 meet a line from 2 to 3)

$P = \frac{1}{2} (1-3)$  (that is half way along the edge 1-3)

$r(K-P) = K + \{ (3-4) - (k-4) \}$  ( r is located on the K-P line at a distance from K of the edge 3-4 (i.e. the length of the side of the square), less half of the diagonal length from by K to 4

The generator  $G^1$  is now defined as  $G^1 = P - K - r - 3$  that is connect K to P then P to r and finally to 3.

$G^2 = G^1 + M^{(h)} G^1$ , this tell us to mirror the generator on the horizontal axis.

$G^3 = G^2 + M^{(d)} G^2$ , this tells us to mirror  $G^2$  on the diagonal axis and finally on the other diagonal. Naturally in the full version of the language it will be necessary to show which diagonal is involved.

$G^4 = G^3 = M^{(d)} G^3$

Note:-It is also possible to define the bird base from the generator by adding rotations for  $90^\circ$ ,  $180^\circ$  and  $270^\circ$

Finally we need to add a fold line from 1 to 4 to permit the fold to be finally flattened. As far as I can see there is only one pattern of mountain and valley folds which will now create a flat fold along these crease lines, and that is the classical bird base.

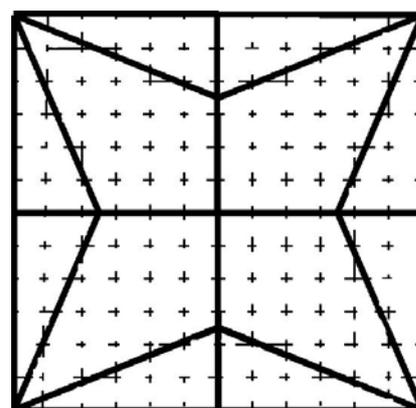
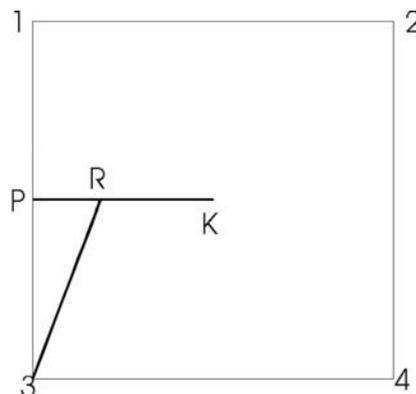
I have looked at many traditional models and bases and found that they all seem to have very simple generators. The kite and fish bases use a diagonal axis for and this is true for the simple swan as well. Flower shapes such as the lilly uses a 4 rotational symmetry, it is interesting that that the bird base uses a 4 fold symmetry also, but this is needed for the head, tail and wings which are in a sense modifications of a 4 fold petal shape.

The bird base is important in classical Origami, so I wondered how close I could approach it using a regular grid pattern

I found the best approximation was to use a 22.5. The tangent for 22.5 degrees is 0.4142136 so are linear error is approximately.06%. This seems a very good fit and I have constructed a very convincing bird base using a 13 by 13 grid in this manner. 13 by 13 grid. This gave a fold line which could be constructed from a corner to 5/12 along the opposite side. This gave a decimal fraction of .4166666 of the side, and means an opposite angle of 22.61985 degrees which is close to the bird base angle of 22.5 degrees.

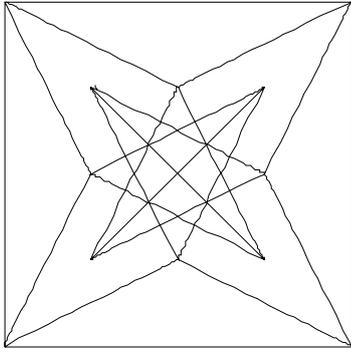
This diagram shows a 1 x 1 square with the lower line connecting the left hand corner with 5/12 th up the opposite side. For comparison a 22.5 degree line is drawn above , it is evident that at this scale the two lines appear to be parallel, hence the 5/12<sup>th</sup> is a good approximation.

I have experimented with the 13 by 13 grid to see if the typical points of a bird base would occur using sampling methods. Perhaps not surprisingly this did not happen, I did consider using special constraints to force the required shapes but rejected them as too complex and cumbersome. During my research I also used the 13 nodes of the bird base as the grid but found little to commend it. The use of circular or logarithmic grids did not, in practice , show any advantage over the regular patterns.



It is worth noting at this point that most classical Origami every fold goes to a boundary and is located from the original corners or sides or derived fold lines. In SNOW folds go between nodes on the grid and may well not reach a boundary. Thus SNOW lacks the admirable simplicity of classical Origami in locating and making the folds. It should be noted, however, that many modern models avoid creases which are not needed, so as to add to the elegance and produce smooth curves in 3D forms and this may well entail making folds which do not reach a boundary.

### 13. The problem of small enclosures in SNOW and the relevance to Classical Origami



When I tried out sequential symmetrical operations on a generator I found a strange problem emerging. As the lines dictated by the generator and the symmetrical operations were achieved I found small enclosures resulting which were not only difficult, if not impossible, to fold but they interfered with the elegance of the curves and the simplicity of the final structure.

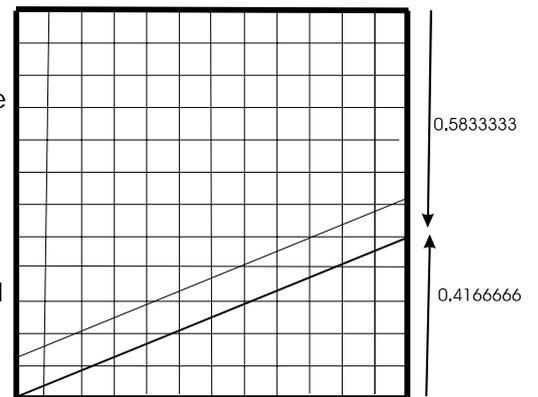
The problem can be illustrated in this picture, although the generator only used 4 nodes the result of mirroring and rotating has led to a number of small enclosures which would be very difficult to fold and use in a manner likely to

enhance the final model.

I have experimented with many different ways of trying to avoid such enclosures without weakening the potentially interesting structures which the random process might throw up. I have tried, for example, to limit the generator to one quarter of the square but soon found that symmetric operations could still create the unwanted small enclosures.

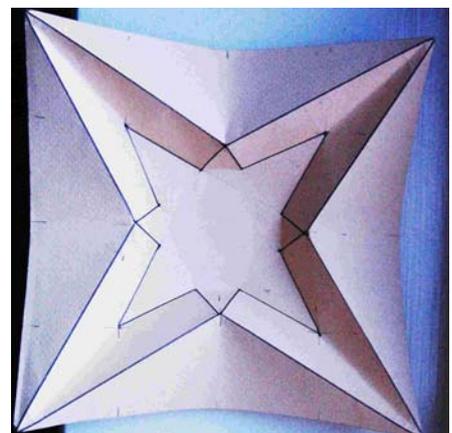
One method which seems to work but at the expense possibly of over stylisation of the resultant shapes is by having a restriction that a line required by the symmetry (or possibly the generator) must terminate at the first junction with another line.

This picture shows the result of applying such a rule to the diagram above. This is not a particularly interesting result and I have doubts about the value of such a rule. It is perfectly possibly simply only to use those fold lines which lead to promising shapes but I would like to solve the problem at its source. Certainly it is helpful to avoid too many nodes being used for the generator, and to choose as few symmetric operations as possible.

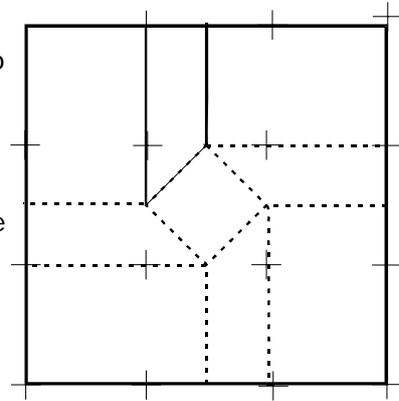


Of course some symmetric operations do not pose such problems, for example translation avoids the kind of line crossing which leads to small enclosures.

A very attractive solution is to use tiling. This avoids the problem of inter crossing folds and also points to a new and very promising technique for SNOW creations. The Bird Base can also be regarded as a 2 x 2 tiling of the generator Tile



This study has again led me to think about classical Origami. I wondered why the problems of small enclosures do not seem to arise. I looked at an interesting example typical of traditional Origami. The nodes in this example are actually those found in a 4 x 4 grid of the kind that I have already described. The generator has been marked with thick black lines the dotted lines show the result of rotation. When this is folded it gives the well known 'twist' structure with the square central enclosure on top. This is the kind of manipulation exploited so well by Fujimoto and then in complex tessellations by Bateman, Fuse, Palmer and others.



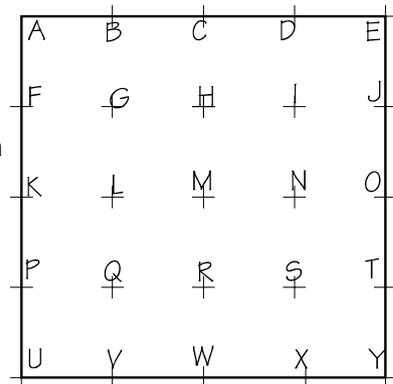
But why, I wondered, does this work as an enclosure? A close study show that each of the four corners of the enclosure satisfy the requirements for folds that can be flattened. In general it seems to me that most Origami exhibits a clear cut structure. All the nodes are located originally from the corners of the paper, later some are located by creases meeting the edge of the paper or another fold. Most folds are based on nodal points and because of the folding methods normally employed sooner or later in the folding sequence arrive at a configuration which can be flattened. These methods therefore in moving from nodes to folds which can be flattened at the nodal point mean that unwanted enclosures do not occur.

#### 14. Choosing generator nodes and SNOW names

There are, of course, many ways of choosing the nodes for a generator. I have already mentioned the use of random numbers and shown the way the sequence chosen can be connected by fold lines. It is not necessary to connect all the random numbers consecutively, they can be connected in smaller groups, for example in a five node generator we may have the first three numbers connected and then a separate group of two.

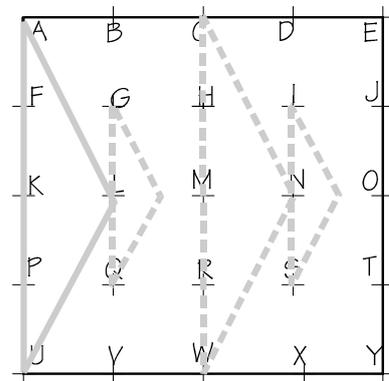
I have not explored these ideas preferring to stay with the simplest approach until I had built up some experience in the procedures of SNOW.

One concept I have worked on is the interesting idea of folding a name. To do this I use a 5 x 5 Grid and allocate to each node a letter of the alphabet, as shown in this illustration. I have omitted Z so as to use only the 25 nodes. The letter X could have been omitted if preferred or, perhaps Y and Z sharing node 25.



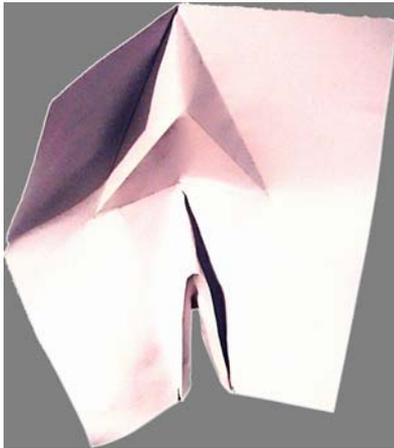
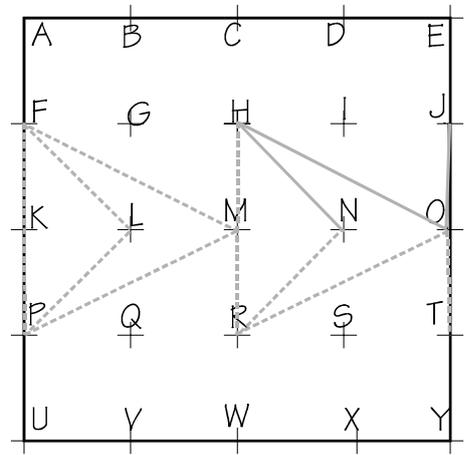
Using this grid I created a SNOW model for Paula Versnick.

I selected the nodes in order of Paula, so P A and U go up and down the side of the square but connect through L. I then scaled the shape to half size and translated it (moved) to the right, shown in the dotted outline. The combined triangles were then translated to the right as shown.



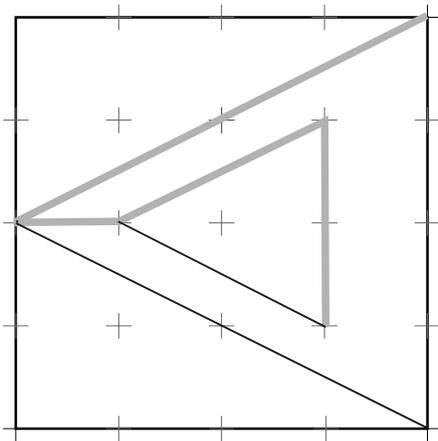
After many experiments I came up with the figure shown here which, of course, I call Paula.

As an additional test of the ideas I thought I would try my own name JOHN. The original Generator is shown as a solid line. Then I reflected this on the central horizontal axis (shown as dotted lines) and then translated the configuration to the left.

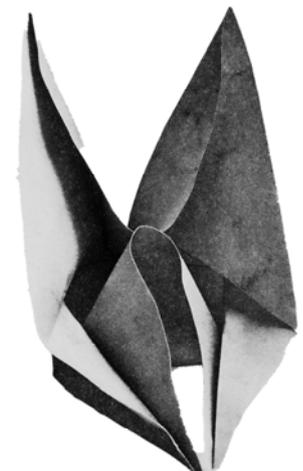
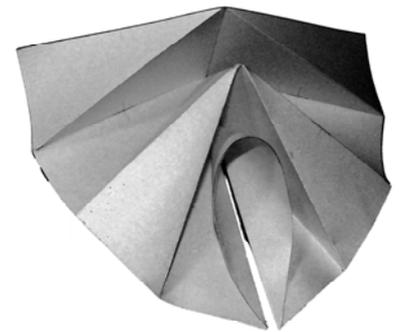
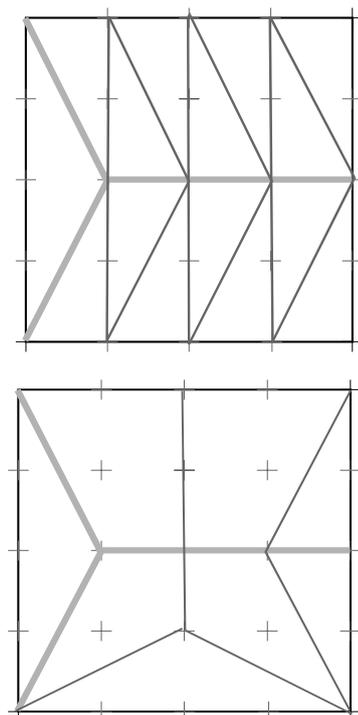


This is the result, I call it 'Paper Face' as it suggested a rather sad face emerging from the in-curved sheet. Of course, by changing the configuration of valley and mountain folds, other shapes may emerge. This is one of the fascinations for me, I could never guess at the shapes that emerge from just one set of possible fold lines. Many are interesting and worth preserving, they are quite unlike anything I have achieved in 'classical Origami' methods

This is a SNOW fold I created from the name Silke.



And the two below were created from the name Paulo

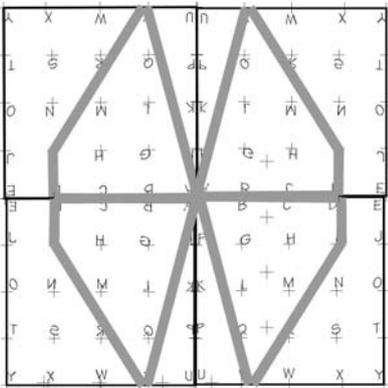
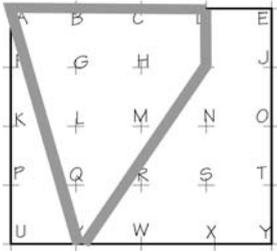


## 15 Tiling

I have already discussed the problem of small enclosures (13). A way of avoiding the problem is to use tiles (or tessellation). This has the effect also of increasing the richness of fold patterns and perhaps lead to being able to select a desired outcome of the fold pattern.

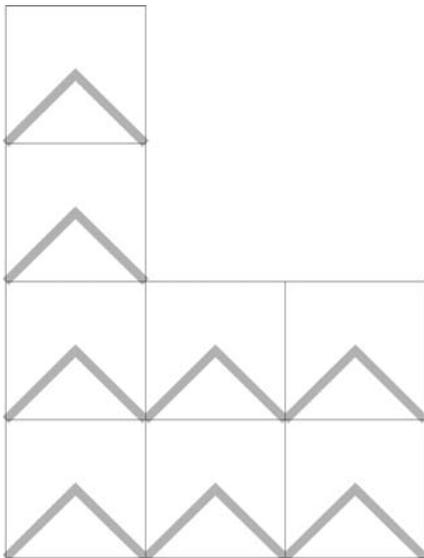
The area of the paper is divided up into tiles, the generator is loaded on one of the tiles and then repeated on the others. Naturally any transformation may be used on the generating tile and on the tiles which repeat the pattern.

To make this clear look at the following examples: -



Note the thick grey lines are the generators

The first diagram shows a 5 x 5 alpha grid with DAVID selected. This is used to make a 4-tiled array shown in the second diagram. A fold which resulted from this array is given in the picture.



Another example

A very simple generator is used and then repeated in each tile as partially shown in the diagram. A result from folding this is shown in the picture.

## 16 The future of SNOW

I wanted to give the ideas I have been describing in this paper an easily remembered name. After many trials I settled on SNOW which stands for Symmetric Nodal Origami World (or Work).

SNOW exhibits a strength which is also its weakness. In the form I have described here SNOW does not have a target form, a particular animal or box etc. I have not found any method of visualising what the outcome will from the fold lines.

SNOW is very unlikely to alight on configurations which can be flattened, which are the main characteristic of traditional Origami. But in SNOW I have found a challenge to the traditional methods, SNOW is essential 3D with induced curves, or curves which seem to arise naturally as a result of folding on the lines connecting the nodes. It is very easy to be repetitive in SNOW by using 4 Fold symmetry but the use of translation and scaling can yield new riches.

I have made a few attempts to see if particular symmetries and generators could lead to a greater ability to decide at the outset the kind of shape one wants to achieve. These are very difficult and deep studies to undertake and I hope people better qualified than I am will take up the challenge.

In a special sense I have found SNOW has aided my understanding of traditional paper folding. The earliest models used simple symmetric bases and then modified the resultant points to achieve the shape desired. Neal Elias began to design the base to suit the result he was aiming at. Fujimoto explored and exploited geometric bases but these all came from nodes originating from the corners of the paper and usually nodal configurations which were related to flattenable forms.

Lang and Kawahata began to systematise the design of a base to achieve the required number of points and the relative distances between them for the target model. A major change in this approach is found in the remarkable work of Huffman who uses mathematical designs to achieve the shapes and their locking he desired (particularly in the use of curved folds). I do not know how he located the required folds on his paper, presumably by using a computer printout.

So is there any future in SNOW? I certainly hope so, I have looked at changing the grids into structures like the bird base nodes but the problems still remain. Of course SNOW can simply be used as a starting point and the folder can go on to add classical points etc. as he or she wishes. For myself I like the 3D curves which arise in SNOW and the challenges to find a final shape which is interesting and attractive, and I would rather stay with the simplest uses of the nodes I have described here.

SNOW has been a special journey for me in that it has brought together many of the ideas and preferences I have developed in my Origami. OIL has given me a language with which to write down the Generators and fold lines. CURIO (CURve Induced Origami), has been an interest of mine for some time, in which the curves in the paper are induced by the crease lines not by sculpting the paper. I have a great interest in abstract folding which suggests Organic forms. Yoshizawa and Kasahara have both shown very interesting work in this field.

SNOW has brought all these elements together for me. I hope other people may find a pleasure in this strange new world.

John S Smith