

Update Report 1

How Was The Evidence Collected?

This document is one of a series of brief updates on the development of a UK National Strategy for Additive Manufacturing / 3D printing (AM-3DP). Information on the background to the development of the strategy is provided at www.amnationalstrategy.uk.

This report summarises the process used to collect evidence on the barriers and opportunities for the adoption of AM-3DP in the UK as perceived during the Spring-Summer 2015 by a broad range of UK stakeholders.

Evidence Collection Process

The process of evidence collection combined stakeholder workshops with an on-line submission of evidence. Three workshops were held in the period March-June 2015 and the on-line submission of evidence ran from April-June 2015. Representatives of 143 organisations provided input via these two channels. The breakdown of the organisations' sectors is given in Table 1. The initial analysis of the results of this process can be found in Update Report 2.

Table 1

(Note: total is greater than 100% as organisations can be tagged in more than one sector)

| Sector | % of contributions |
|---------------------|--------------------|
| Manufacturing | 55 |
| Materials | 34 |
| Machinery | 19 |
| Information | 10 |
| Aerospace | 12 |
| Defence | 10 |
| Creative industries | 7 |
| Life sciences | 5 |
| Automotive | 3 |
| Motorsport | 3 |
| Nuclear | 3 |
| Electronics | 3 |
| Construction | 1 |
| Rail | 1 |
| Marine | 1 |

Workshops

Details of the three workshops¹ held are given below.

Table 2

| Date | 10 th March 2015 | 25 th March 2015 | 25 th June 2015 |
|---------------|---------------------------------|-----------------------------|---------------------------------|
| Venue | Manufacturing Technology Centre | University of Nottingham | Manufacturing Technology Centre |
| Participation | Open | Open | Motorsport related |
| Attendees | 111 | 32 | 20 |

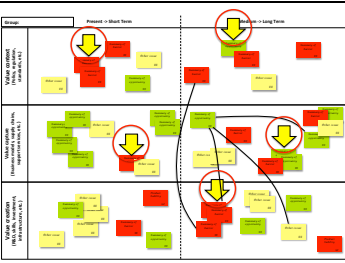

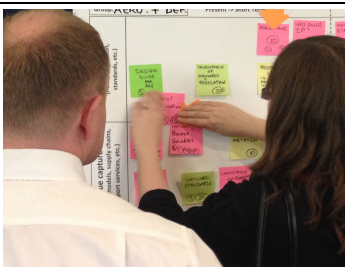

A common process² was used at all three events. Attendees were organised into groups (loosely aligned to their primary sector affiliations) and given the task of discussing their individual perceptions of opportunities, barriers and other issues relating to the adoption of AM-3DP in the UK. These perceptions were then noted on colour-specific Post-It notes (Green = opportunity; Red/pink = barrier; Yellow = unspecified) and placed onto a mapping template. To preserve anonymity but allow for the organisers to link individual contributions to attendees' organisation and sector during the evidence analysis process, contributors wrote their delegate number on each Post-It added to the map. There was then an opportunity to highlight linkages between the issues. Members of each group then voted on the top 3-5 issues on their map that they felt were of particular relevance for further analysis, and highlighted these with arrows.

¹ The original intent had been to run only one workshop as part of the evidence gathering process on 10th March. However, the level of interest combined with capacity constraints at the venue led to a second open event being held later that month. Analysis of attendees revealed an absence of attendees related to motorsport, so an event specifically for that community was held in June.

² The process drew upon lessons from the development of Technology Roadmaps (www.ifm.eng.cam.ac.uk/roadmapping/).

All attendees were then given a chance to review a full set of the maps, and to provide comments on any arising issues. After the event, input from all of the 848 Post-Its was captured in a spreadsheet. A summary of the process is illustrated in Table 3.

Table 3

| <p>Sample template</p> |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|--|--|---|----------------------|---|----------|--------|-------|----|-------|------------|------|----|----|---|---------------------|------------|------|----|--|---|---|------------|------|----|--|---|--|------------|------|----|--|---|-------------------|------------|------|----|--|---|------------------------------|------------|------|----|--|---|--|------------|------|----|--|---|--|------------|------|----|--|---|-------------------------------|------------|------|----|--|----|---------------------------------------|------------|------|----|--|----|---------------------|------------|------|----|--|----|--|------------|------|----|--|----|--|------------|------|----|--|----|---|------------|------|----|--|
| <p>Discussion</p> |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Capturing views on a map</p> |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Discussion of a finished map</p> |  | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Coding</p> | <table border="1" data-bbox="389 1576 735 1809"> <thead> <tr> <th></th> <th>Process - Short Term</th> <th>Medium - Long Term</th> </tr> </thead> <tbody> <tr> <td>A1</td> <td></td> <td>A2</td> </tr> <tr> <td>B1</td> <td></td> <td>B2</td> </tr> <tr> <td>C1</td> <td></td> <td>C2</td> </tr> </tbody> </table> | | Process - Short Term | Medium - Long Term | A1 | | A2 | B1 | | B2 | C1 | | C2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | Process - Short Term | Medium - Long Term | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| A1 | | A2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| B1 | | B2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| C1 | | C2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| <p>Sample worksheet</p> | <table border="1" data-bbox="389 1823 735 2004"> <thead> <tr> <th>Code</th> <th>Comment</th> <th>Category (Short-term, Medium-term, Long-term)</th> <th>Priority</th> <th>Impact</th> <th>Notes</th> </tr> </thead> <tbody> <tr> <td>1</td> <td>Costs</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>2</td> <td>Quality consistency</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>3</td> <td>Reduce time to market (performance of process) - reduce 10 minutes versus 30 mins</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>4</td> <td>Reduce production (particular) (logistics) materials</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>5</td> <td>Parts integration</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>6</td> <td>Better electrical properties</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>7</td> <td>Enhanced mechanical properties (strength) after 1000 hours testing</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>8</td> <td>Higher consistency - better surface finish</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>9</td> <td>Very short lead time possible</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>10</td> <td>Reduced process cost (PDM) (machines)</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>11</td> <td>Speed of production</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>12</td> <td>Reduced cost (per unit) (reduced efficiency)</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>13</td> <td>High temperature polymer (or plastic) - high cost e.g. 10000</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> <tr> <td>14</td> <td>Continuous connected build process in use</td> <td>Short-term</td> <td>High</td> <td>10</td> <td></td> </tr> </tbody> </table> | Code | Comment | Category (Short-term, Medium-term, Long-term) | Priority | Impact | Notes | 1 | Costs | Short-term | High | 10 | | 2 | Quality consistency | Short-term | High | 10 | | 3 | Reduce time to market (performance of process) - reduce 10 minutes versus 30 mins | Short-term | High | 10 | | 4 | Reduce production (particular) (logistics) materials | Short-term | High | 10 | | 5 | Parts integration | Short-term | High | 10 | | 6 | Better electrical properties | Short-term | High | 10 | | 7 | Enhanced mechanical properties (strength) after 1000 hours testing | Short-term | High | 10 | | 8 | Higher consistency - better surface finish | Short-term | High | 10 | | 9 | Very short lead time possible | Short-term | High | 10 | | 10 | Reduced process cost (PDM) (machines) | Short-term | High | 10 | | 11 | Speed of production | Short-term | High | 10 | | 12 | Reduced cost (per unit) (reduced efficiency) | Short-term | High | 10 | | 13 | High temperature polymer (or plastic) - high cost e.g. 10000 | Short-term | High | 10 | | 14 | Continuous connected build process in use | Short-term | High | 10 | |
| Code | Comment | Category (Short-term, Medium-term, Long-term) | Priority | Impact | Notes | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1 | Costs | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 2 | Quality consistency | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 3 | Reduce time to market (performance of process) - reduce 10 minutes versus 30 mins | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 4 | Reduce production (particular) (logistics) materials | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 5 | Parts integration | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 6 | Better electrical properties | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 7 | Enhanced mechanical properties (strength) after 1000 hours testing | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 8 | Higher consistency - better surface finish | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 9 | Very short lead time possible | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 10 | Reduced process cost (PDM) (machines) | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 11 | Speed of production | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 12 | Reduced cost (per unit) (reduced efficiency) | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 13 | High temperature polymer (or plastic) - high cost e.g. 10000 | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 14 | Continuous connected build process in use | Short-term | High | 10 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |

On-line submission of evidence

An open call for evidence was promoted via the workshops, email lists and social media. The main UK National Strategy for AM-3DP website (www.amnationalstrategy.uk) was used as a portal for electronic submissions of evidence.

The website allowed submissions to be made in a variety of formats, ranging from unconstrained (e.g. existing reports, sources of data, or any comments could be emailed directly to the research team) to constrained (e.g. an on-line form requesting responses to specific questions derived in part from issues raised at the workshops). The constrained submissions could be made either using a Qualtrics³ survey tool, or via a Microsoft Word form.

Submissions could be made on behalf of individuals, organisations or communities. Contributors were also informed that, by default, all evidence submitted would only published in aggregate form.

When the Call for Evidence was closed, 56 fully completed responses to the on-line form were received, along with numerous reports, papers, presentations and other sources of data.

Analysis of the evidence

Analysis of the evidence is being undertaken in two stages. An initial analysis was completed in September 2015 and published as Update Report 2 (downloadable from the UK National Strategy for AM-3DP website). This forms a key input into the design of activities for the next stage of the strategy development process. In addition, a more detailed analysis of the evidence captured is currently being conducted, and findings from this will be published in further updates during Q4 2015.

Wherever possible (subject to confidentiality issues), data captured during the development of the UK National Strategy for AM-3DP will be made publicly and freely available via www.amnationalstrategy.uk.

Professor Phill Dickens and Dr Tim Minshall

October 2015

³ <http://www.qualtrics.com/>