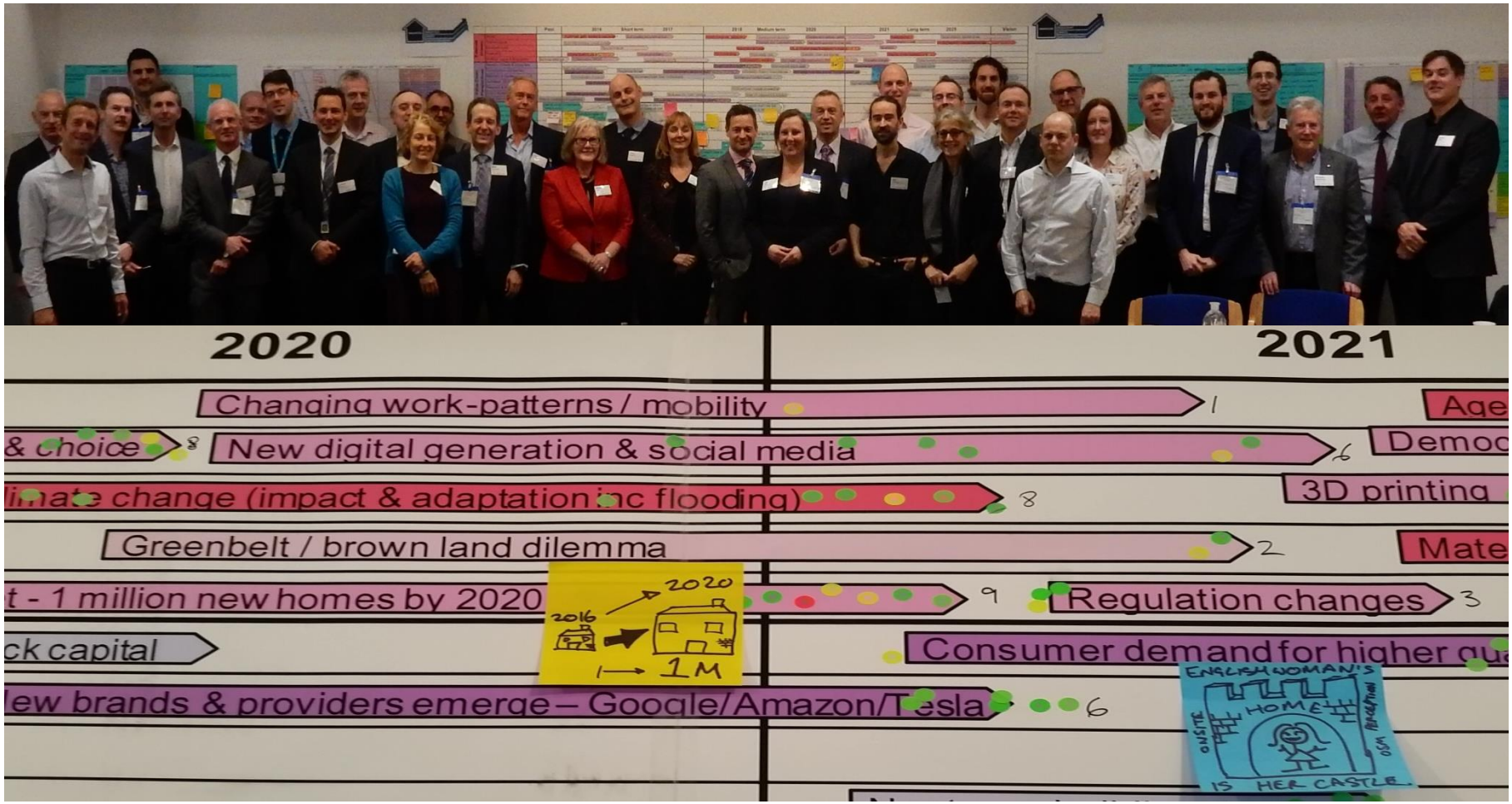
Construction Leadership Council Innovation Workstream (Buildings)

Roadmap for Modern Methods of Construction (MMC)

Workshop Report Issue 1.0 April 2016



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Executive Summary

Background & Aims

This report results from a one-day workshop organised by Saint-Gobain and the Construction Leadership Council and hosted by BIS in London on 7 April 2016. The aim of the workshop was to help develop a strategic roadmap of barriers to take-up and commercialisation of Modern Methods of Construction (MMC), and develop solutions to help increase the percentage of new buildings built using, substantially, MMC. The aim is to improve productivity, capacity and the use of innovation in the housing sector by removing barriers to progress and helping the industry to move the new methods from development through to actual commercial use and thereby increase housing supply.

The scope of the workshop comprised:

- Focussing on homes, but with a view to expanding to consider all building types later, and predominantly new build rather than retrofit of buildings.
- Innovative solutions to address increased supply of housing; quality and performance; environmental performance; and adaptation to climate, will all be considered.
- Includes SMART technologies where this will help to improve productivity.

The workshop benefitted from the insights of over 40 experts from across the construction value chain. This Workshop Report is intended to capture the raw outputs of the workshop which will be used by the Construction Leadership Council to develop an action plan to overcome key blockages in deploying MMC.

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Executive Summary (cont)

Key External Drivers which will shape MMC adoption include:

- Housing Supply Shortage
- Gov't target - 1 million new homes by 2020
- Climate change (impact & adaptation including flooding)
- Growth of inner-city developments
- Increasing population, migration & urban density
- Personalisation, customisation & choice
- New digital generation & social media
- AI, Big Data & IoT - Second Machine Age technologies
- Democratisation of Data
- Materials & water shortages / cost increases

Major Issues within the Construction Value-Chain relating to MMC include:

- Lack of construction skills (esp for MMC)
- Consumer demand for higher quality / performance
- Growth in Build-to-Rent/PRS
- Mass customisation of house types => Platform approach
- Investors need to demonstrate ROI > Speed & certainty
- Wider UK collaboration & standards for compatibility
- Automation of construction processes
- New brands & providers emerge – Google/Amazon/Tesla
- Risk-averse culture (at time of rising demand)
- Emergence of standard housing components (eg automotive model)

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Executive Summary (cont)

The Major Barriers to MMC adoption are seen as:

- Lack of collaboration, and a need for strategic partnerships within the supply chain
- Lending, valuation & Insurance: Concerns over product durability & equity retention
- Lack of demand; with consumers unaware of MMC innovation or its potential benefits to deliver better, safer, cleaner, faster etc building at same cost
- Immature supply chain, with a need to move towards an automotive-industry model: component > sub-assembly > building assembly
- Risk-averse culture in construction
- Fragmented procurement and a need for new models
- Investment needed in MMC suppliers for economies of scale. This requires volume surety amidst volatile demand and aggregated volumes through standardisation
- Business case for change, and the ability to demonstrate benefits through performance data & running costs for real OSM housing
- Trade skills shortage in MMC
- Consumer resistance, with MMC associated with “pre-fab” not "bricks & mortar"
- Need for industry leadership (& a Roadmap) for adoption

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Executive Summary (cont)

Innovations and Technologies which are applicable to overcome these barriers include:

- BIM as a digitally enabling platform
- Standardisation BUT with choice…
- Integrated CAD/CAM from design to site
- Factory productivity drives down component costs
- Cost modelling tools & performance data > life-cycle benefits
- Robotics and automation – on site or factory
- Project & building assembly sequencing
- Sensors, communications & RFID technologies (embedded in OSC modules)
- Smart / Intelligent buildings (for added value / functionality)
- New homes designed to balance energy demand

Other Enablers necessary for success to overcome these barriers include:

- Supply chain collaborative innovation
- Demonstration schemes and sites
- Insurance industry to support MMC
- Support for construction R&D
- Long-term partnering & pipeline visibility enables supply chain investment
- New development & business models (eg ownership + rental)
- Technology & knowledge transfer from outside sector
- Case studies for clients
- OSM standards enable collaboration & QA
- Mortgage-ability eg BOPAS

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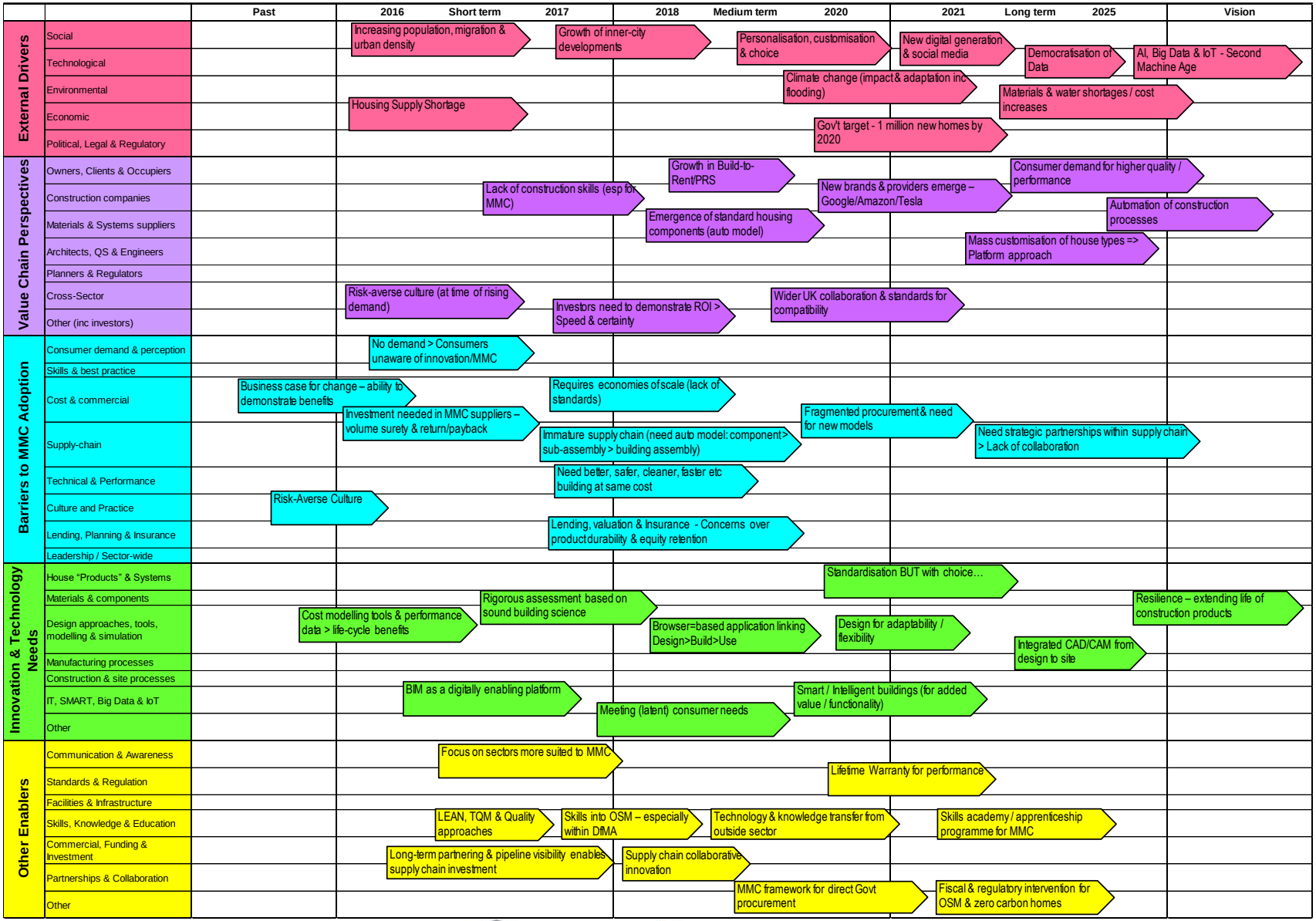
Contents

1.1. Roadmap Landscape (Headlines)



Note: See report for readable detail.
Deeper colours indicate higher priority items.

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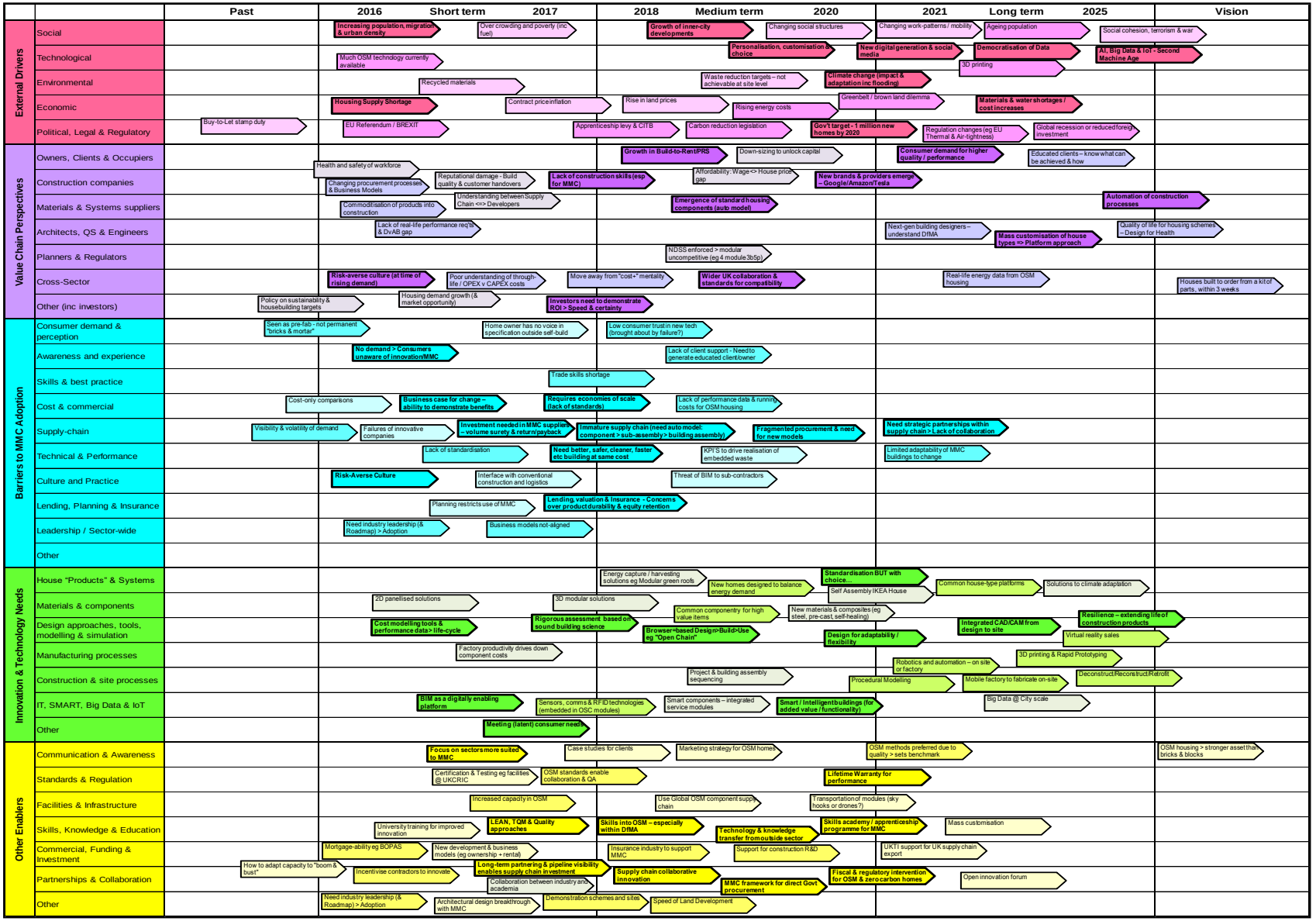
1.2. Roadmap Landscape (Detail)



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1.3. Landscape Linkages (Headlines)

External Drivers										Value Chain Perspectives												Innovation & Technology Needs										Other Enablers										
Housing Supply Shortage	Carbon reduction legislation	Waste reduction targets – not achievable at site level	Gov't target - 1 million new homes by 2020	Personalisation, customisation & choice	AI, Big Data & IoT - Second Machine Age	Regulation changes (eg EU Thermal & Air-tightness)	Growth of inner-city developments	Contract price inflation	Materials & water shortages / cost increases	Lack of construction skills (esp for MMC)	Wider UK collaboration & standards for compatibility	Understanding between Supply Chain <=> Developers	Reputational damage - Build quality & customer handovers	Automation of construction processes	Consumer demand for higher quality / performance	Changing procurement processes & Business Models	Risk-averse culture (at time of rising demand)	Investors need to demonstrate ROI > Speed & certainty	Housing demand growth (& market opportunity)			BIM as a digitally enabling platform	Standardisation BUT with choice...	Integrated CAD/CAM from design to site	Factory productivity drives down component costs	Cost modelling tools & performance data > life-cycle benefits	Robotics and automation – on site or factory	Project & building assembly sequencing	Sensors, comms & RFID technologies (embedded in OSC modules)	Smart / Intelligent buildings (for added value / functionality)	New homes designed to balance energy demand	Supply chain collaborative innovation	Demonstration schemes and sites	Insurance industry to support MMC	Support for construction R&D	Long-term partnering & pipeline visibility enables supply chain investme	New development & business models (eg ownership + rental)	Technology & knowledge transfer from outside sector	Case studies for clients	OSM standards enable collaboration & QA	Mortgage-ability eg BOPAS	
1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10		Barriers to MMC Adoption		1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10	
1		1	1				1		1	1	1	1		1		1			1	A	Need strategic partnerships within supply chain > Lack of collaboration	11	1			1	1			1			1		1	1	1	1	1	1		1	12
	1			1	1	1					1		1		1					B	No demand > passive consumers unaware of MMC inc poor perception of "pre-fab"	7					1			1	1	1		1	1		1		1		1	9
1			1				1	1			1					1			1	C	Investment needed in MMC suppliers – volume surety & volatility	7	1	1		1	1	1	1				1	1		1	1		1	1	1	13
1	1			1						1	1	1	1		1		1	1		D	Lending, valuation & Insurance - Concerns over product durability & equity retention	10		1						1				1	1					1		5
1		1	1	1			1			1	1	1	1	1		1		1	1	E	Immature supply chain (need auto model: component > sub-assembly > building assembly)	13	1	1	1	1	1	1	1			1	1	1	1	1		1	1		1		15
1	1	1				1			1	1			1	1			1	1	1	F	Risk-Averse Culture	11	1							1	1	1	1	1		1		1			1	9
		1			1			1		1	1	1	1	1		1	1	1		G	Fragmented procurement & need for new models	11	1	1	1	1	1	1	1		1		1	1		1	1		1	1	1		15
1	1		1	1	1	1				1		1	1		1			1		H	Business case for change – ability to demonstrate benefits	11	1	1	1		1			1			1	1			1			1		9
1	1									1	1	1		1	1		1			I	Need better, safer, cleaner, faster etc building at same cost (not just cost down)	8		1				1		1		1	1	1	1		1					9
		1	1	1	1			1		1	1	1		1	1	1	1		1	J	Requires economies of scale (lack of standards)	13	1	1	1	1		1	1	1	1		1	1		1	1	1	1		1	15
	1				1	1			1				1		1					K	Lack of performance data & running costs for OSM housing	6	1							1	1	1		1	1	1		1	1		1	10
7	6	5	5	5	5	4	3	3	3	8	8	7	7	6	6	5	5	5	5				8	7	5	5	5	5	5	5	5	5	8	8	8	8	6	6	6	6	5	5	

This chart shows how prioritised External Drivers and Value Chain Issues drive the Key Barriers to MMC adoption (left hand side of chart) and in turn, how theses Barriers can be overcome through Innovation, Technology and Other Enablers (Right hand side of chart). Coloured cells at the intersections indicate a linkage identified by the breakout group team.

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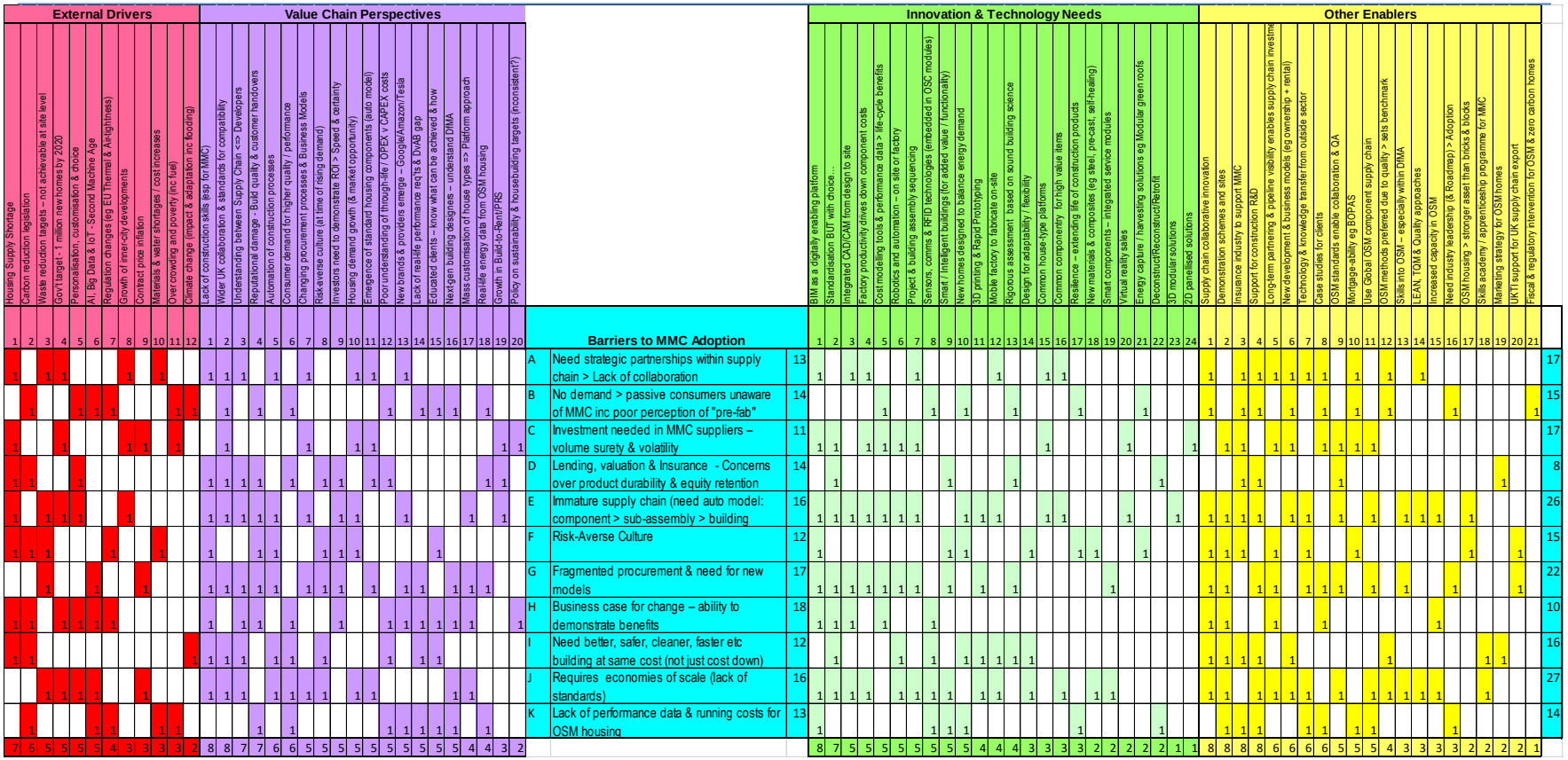
1.4. Landscape Linkages



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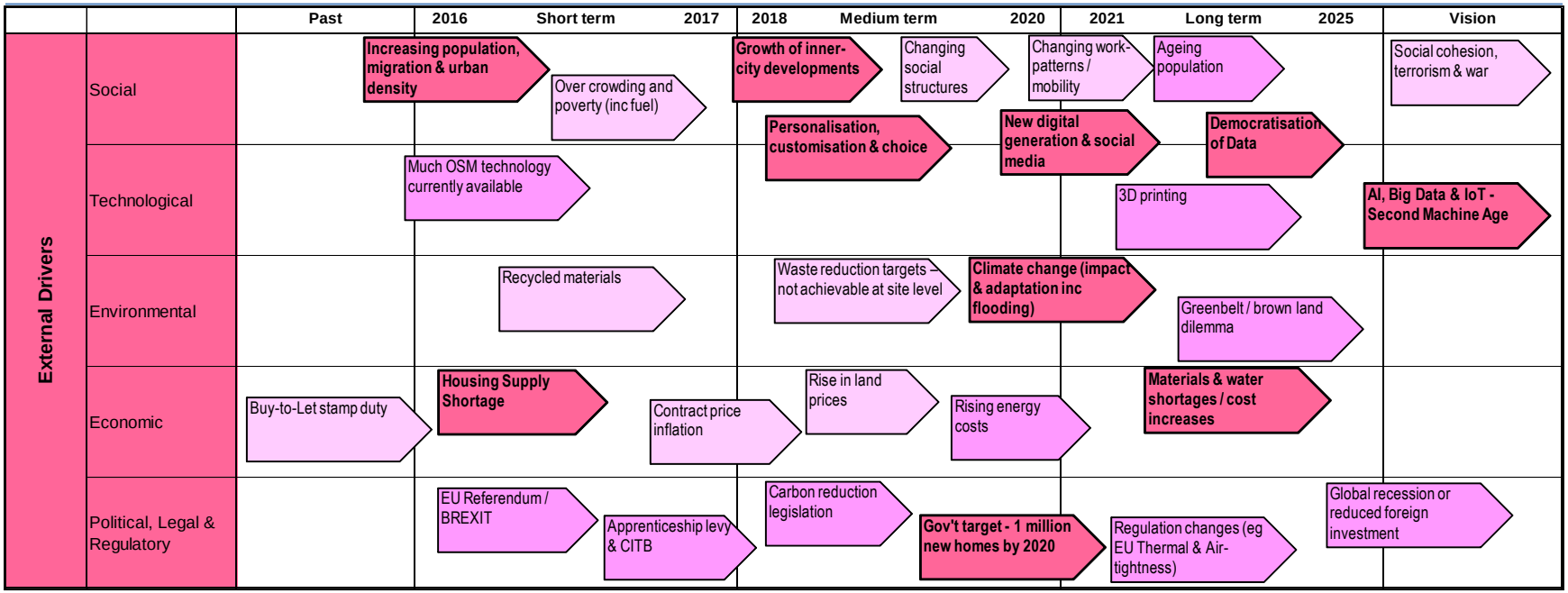
2.1 External Drivers



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2.2 External Drivers (1 to 20)

Rank	External Driver	Pre-work	Timescale	Workshop	%
1	Housing Supply Shortage	11	s	16	16%
2	Gov't target - 1 million new homes by 2020	4	m	9	9%
3	Climate change (impact & adaptation inc flooding)	8	m-l	8	8%
4	Growth of inner-city developments	6	m	8	8%
5	Increasing population, migration & urban density	13	s	8	8%
6	Personalisation, customisation & choice	3	m	8	8%
7	New digital generation & social media	2	m-l	6	6%
8	AI, Big Data & IoT - Second Machine Age	6	l	4	4%
9	Democratisation of Data	3	l	4	4%
10	Materials & water shortages / cost increases	5	m-l	3	3%
11	Regulation changes (eg EU Thermal & Air-tightness)	4	m-l	3	3%
12	Ageing population	4	l	2	2%
13	EU Referendum / BREXIT	3	s-m	2	2%
14	Global recession or reduced foreign investment	1	m	2	2%
15	Greenbelt / brown land dilemma	2	s-l	2	2%
16	Much OSM technology currently available	1	s	2	2%
17	Rising energy costs	2	m-l	2	2%
18	3D printing	2	l	1	1%
19	Apprenticeship levy & CITB	1	m	1	1%
20	Carbon reduction legislation	7	m	1	1%

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2.2 External Drivers (cont)

Rank	External Driver	Pre-work	Timescale	Workshop	%
21	Changing social structures	2	m	1	1%
22	Changing work-patterns / mobility	2	l	1	1%
23	Contract price inflation	4	s-m	1	1%
24	Over crowding and poverty (inc fuel)	3	s	1	1%
25	Rise in land prices	4	m	1	1%
26	Waste reduction targets – not achievable at site level	5	m	1	1%
27	Buy-to-Let stamp duty	1	s	0	0%
28	Recycled materials	1	l	0	0%
29	Social cohesion, terrorism & war	1	l	0	0%

This chart shows how issues were ranked in voting in the workshop (column: Workshop) and also the initial ranking from participant pre-work (column: pre-work) and the timescale (Short, Medium or Long-term) where the issue is most relevant.

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2.3 External Drivers Linkages

Rank	External Driver	Need strategic partnerships within supply chain > Lack of collaboration	No demand > passive consumers unaware of MMC inc poor perception of "pre-fab"	Investment needed in MMC suppliers – volume surety & volatility	Lending, valuation & Insurance - Concerns over product durability & equity retention	Immature supply chain (need auto model: component > sub-assembly > building assembly)	Risk-Averse Culture	Fragmented procurement & need for new models	Business case for change – ability to demonstrate benefits	Need better, safer, cleaner, faster etc building at same cost (no just cost down)	Requires economies of scale (lack of standards)	Lack of performance data & running costs for OSM housing	TOTAL
		A	B	C	D	E	F	G	H	I	J	K	
1	Housing Supply Shortage	1		1	1	1	1		1	1			7
2	Carbon reduction legislation		1		1		1		1	1		1	6
3	Waste reduction targets – not achievable at site level	1				1	1	1			1		5
4	Gov't target - 1 million new homes by 2020	1		1		1			1		1		5
5	Personalisation, customisation & choice		1		1	1			1		1		5
6	AI, Big Data & IoT - Second Machine Age		1					1	1		1	1	5
7	Regulation changes (eg EU Thermal & Air-tightness)		1				1		1			1	4
8	Growth of inner-city developments	1		1		1							3
9	Contract price inflation			1				1			1		3
10	Materials & water shortages / cost increases	1					1					1	3
11	Over crowding and poverty (inc fuel)		1	1								1	3
12	Climate change (impact & adaptation inc flooding)		1							1			2
13	Increasing population, migration & urban density												0
14	Rise in land prices												0
15	Ageing population												0

This chart shows how prioritised External drive the Key Barriers to MMC adoption

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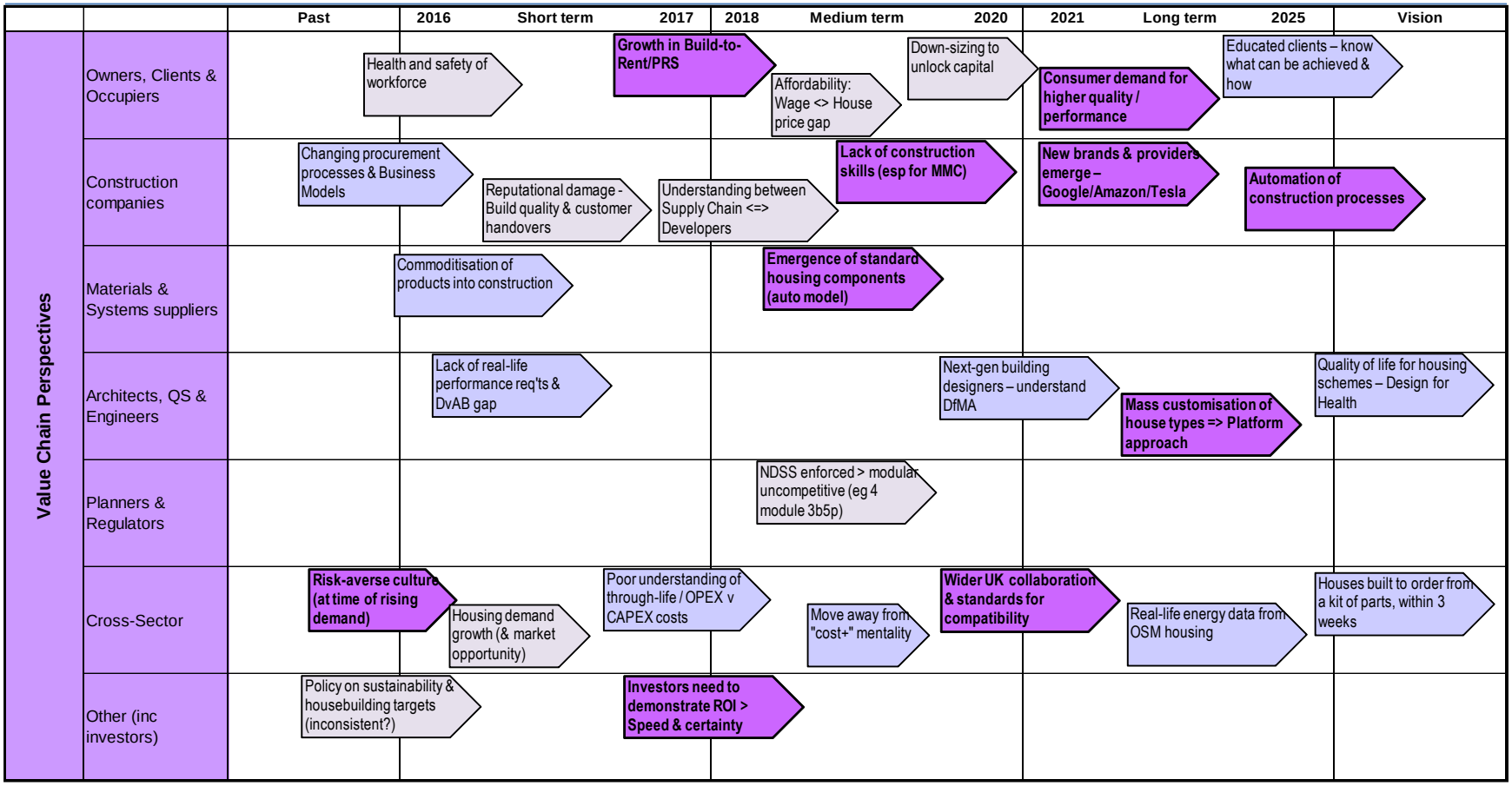
2.4 Value Chain Perspectives



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2.5 Value Chain Perspectives (1 to 20)

Rank	Value Chain Perspectives	Pre-work	Timescale	Workshop	%
1	Lack of construction skills (esp for MMC)	13	s-m	13	10%
2	Consumer demand for higher quality / performance	11	l	11	8%
3	Growth in Build-to-Rent/PRS	8	m	10	8%
4	Mass customisation of house types => Platform approach	4	m-l	9	7%
5	Investors need to demonstrate ROI > Speed & certainty	7	m	8	6%
6	Wider UK collaboration & standards for compatibility	3	s-l	8	6%
7	Automation of construction processes	4	l	7	5%
8	New brands & providers emerge – Google/Amazon/Tesla	7	m-l	6	5%
9	Risk-averse culture (at time of rising demand)	7	s	6	5%
10	Emergence of standard housing components (auto model	5	m	5	4%
11	Lack of real-life performance req'ts & DvAB gap	6	s	5	4%
12	Next-gen building designers – understand DfMA	4	l	5	4%
13	Poor understanding of through-life / OPEX v CAPEX costs	9	s	5	4%
14	Changing procurement processes & Business Models	8	s-m	4	3%
15	Educated clients – know what can be achieved & how	6	l	4	3%
16	Houses built to order from a kit of parts, within 3 weeks	1	v	4	3%
17	Quality of life for housing schemes – Design for Health	3	l	4	3%
18	Commoditisation of products into construction	2	s	3	2%
19	Move away from "cost+" mentality	1	s	3	2%
20	Real-life energy data from OSM housing	5	l	3	2%

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2.5 Value Chain Perspectives (cont)

Rank	Value Chain Perspectives	Pre-work	Timescale	Workshop	%
21	Affordability: Wage <> House price gap	3	s-l	2	2%
22	Housing demand growth (& market opportunity)	7	s	2	2%
23	Reputational damage - Build quality & customer handove	5	s	2	2%
24	Health and safety of workforce	3	s	1	1%
25	NDSS enforced > modular uncompetitive (eg 4 module 3b	1	m	1	1%
26	Understanding between Supply Chain <=> Developers	6	s	1	1%
27	Down-sizing to unlock capital	5	m	0	0%
28	Policy on sustainability & housebuilding targets (inconsist	4	s	0	0%

This chart shows how issues were ranked in voting in the workshop (column: Workshop) and also the initial ranking from participant pre-work (column: pre-work) and the timescale (Short, Medium or Long-term) where the issue is most relevant.

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2.6 Value Chain Perspectives Linkages

Rank	Value Chain Perspectives	Need strategic partnerships within supply chain > Lack of collaboration	No demand > passive consumers unaware of MMC inc poor perception of "pre-fab"	Investment needed in MMC suppliers – volume surety & volatility	Lending, valuation & Insurance - Concerns over product durability & equity retention	Immature supply chain (need auto model: component > sub-assembly > building assembly)	Risk-Averse Culture	Fragmented procurement & need for new models	Business case for change – ability to demonstrate benefits	Need better, safer, cleaner, faster etc building at same cost (no just cost down)	Requires economies of scale (lack of standards)	Lack of performance data & running costs for OSM housing	TOTAL
		A	B	C	D	E	F	G	H	I	J	K	
1	Lack of construction skills (esp for MMC)	1			1	1	1	1	1	1	1		8
2	Wider UK collaboration & standards for compatibility	1	1	1	1	1		1		1	1		8
3	Understanding between Supply Chain <=> Developers	1			1	1		1	1	1	1		7
4	Reputational damage - Build quality & customer handovers		1		1	1	1	1	1			1	7
5	Automation of construction processes	1				1	1	1		1	1		6
6	Consumer demand for higher quality / performance		1		1				1	1	1	1	6
7	Changing procurement processes & Business Models	1		1		1		1			1		5
8	Risk-averse culture (at time of rising demand)				1		1	1		1	1		5
9	Investors need to demonstrate ROI > Speed & certainty				1	1	1	1	1				5
10	Housing demand growth (& market opportunity)	1		1		1	1				1		5
11	Emergence of standard housing components (auto model)	1		1	1			1			1		5
12	Poor understanding of through-life / OPEX v CAPEX costs		1		1				1	1		1	5
13	New brands & providers emerge – Google/Amazon/Tesla	1				1		1	1			1	5
14	Lack of real-life performance req'ts & DvAB gap		1					1	1	1		1	5
15	Educated clients – know what can be achieved & how		1				1		1	1		1	5
16	Next-gen building designers – understand DfMA		1					1	1		1	1	5
17	Mass customisation of house types => Platform approach					1		1	1		1		4
18	Real-life energy data from OSM housing		1		1			1				1	4
19	Growth in Build-to-Rent/PRS			1	1	1							3
20	Policy on sustainability & housebuilding targets (inconsistent?)			1					1				2
21	Down-sizing to unlock capital												0

This chart shows how prioritised Value Chain Issues drive the Key Barriers to MMC

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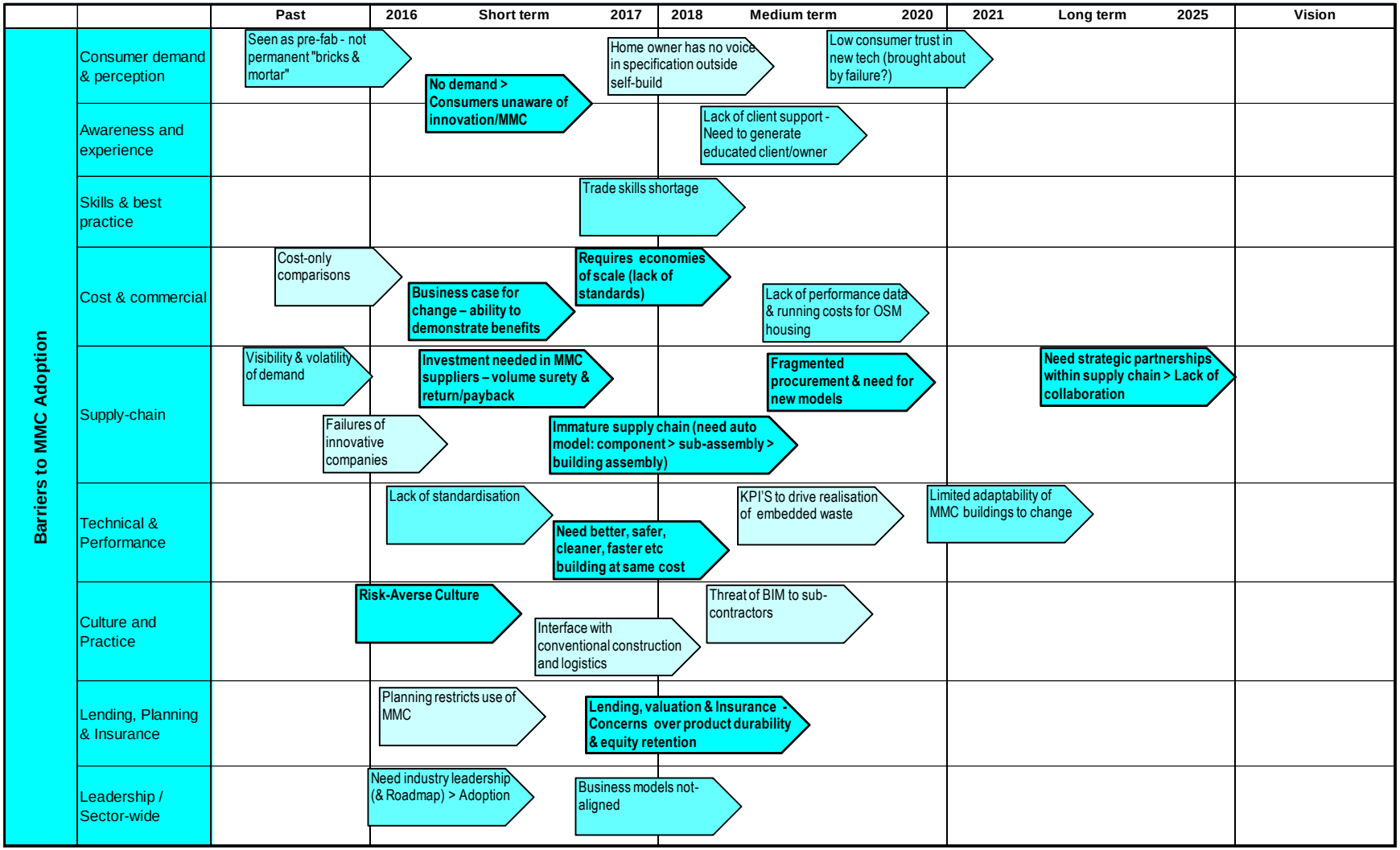
3.1 Barriers to Adoption



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3.2 Barriers to Adoption (1 to 20)

Rank	Barriers	Pre-work	Timescale	Workshop	%
1	Need strategic partnerships within supply chain > Lack of collaboration	5	s-l	27	14%
2	Lending, valuation & Insurance - Concerns over product durability & equity retention	6	s-m	15	8%
3	No demand > Consumers unaware of innovation/MMC	7	s	14	7%
4	Immature supply chain (need automotive model: component > sub-assembly > building assembly)	12	m	14	7%
5	Risk-Averse Culture	7	s	13	7%
6	Fragmented procurement & need for new models	5	m	12	6%
7	Investment needed in MMC suppliers – volume surety & return/payback	7	s-m	11	6%
8	Business case for change – ability to demonstrate benefits	5	s	9	5%
9	Need better, safer, cleaner, faster etc building at same cost	8	s-m	9	5%
10	Requires economies of scale (lack of standards)	9	s-m	8	4%
11	Trade skills shortage	10	s-m	8	4%
12	Lack of performance data & running costs for OSM housing	4	m	7	4%
13	Need industry leadership (& Roadmap) to drive Adoption	2	s-l	7	4%
14	Visibility & volatility of demand	0	m	7	4%
15	Seen as pre-fab - not permanent "bricks & mortar"	14	s	6	3%
16	Business models not-aligned	1	s	4	2%
17	Lack of client support - Need to generate educated client/owner preference for engineered solution	8	m	4	2%
18	Low consumer trust in new tech (brought about by failure?)	5	m	4	2%
19	Lack of standardisation	0	s	4	2%
20	Limited adaptability of MMC buildings to change	2	l	3	2%

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3.2 Barriers to Adoption (cont)

Rank	Barriers	Pre-work	Timescale	Workshop	%
21	Cost-only comparisons	0	s-m	2	1%
22	Home owner has no voice in specification outside self-build	1	s	1	1%
23	Interface with conventional construction and logistics	3	s	1	1%
24	Planning restricts use of MMC	6	s-m	1	1%
25	Threat of BIM to sub-contractors	1	m	1	1%
26	Failures of innovative companies	4	s	0	0%
27	KPI'S to drive realisation of embedded waste	1	m	0	0%

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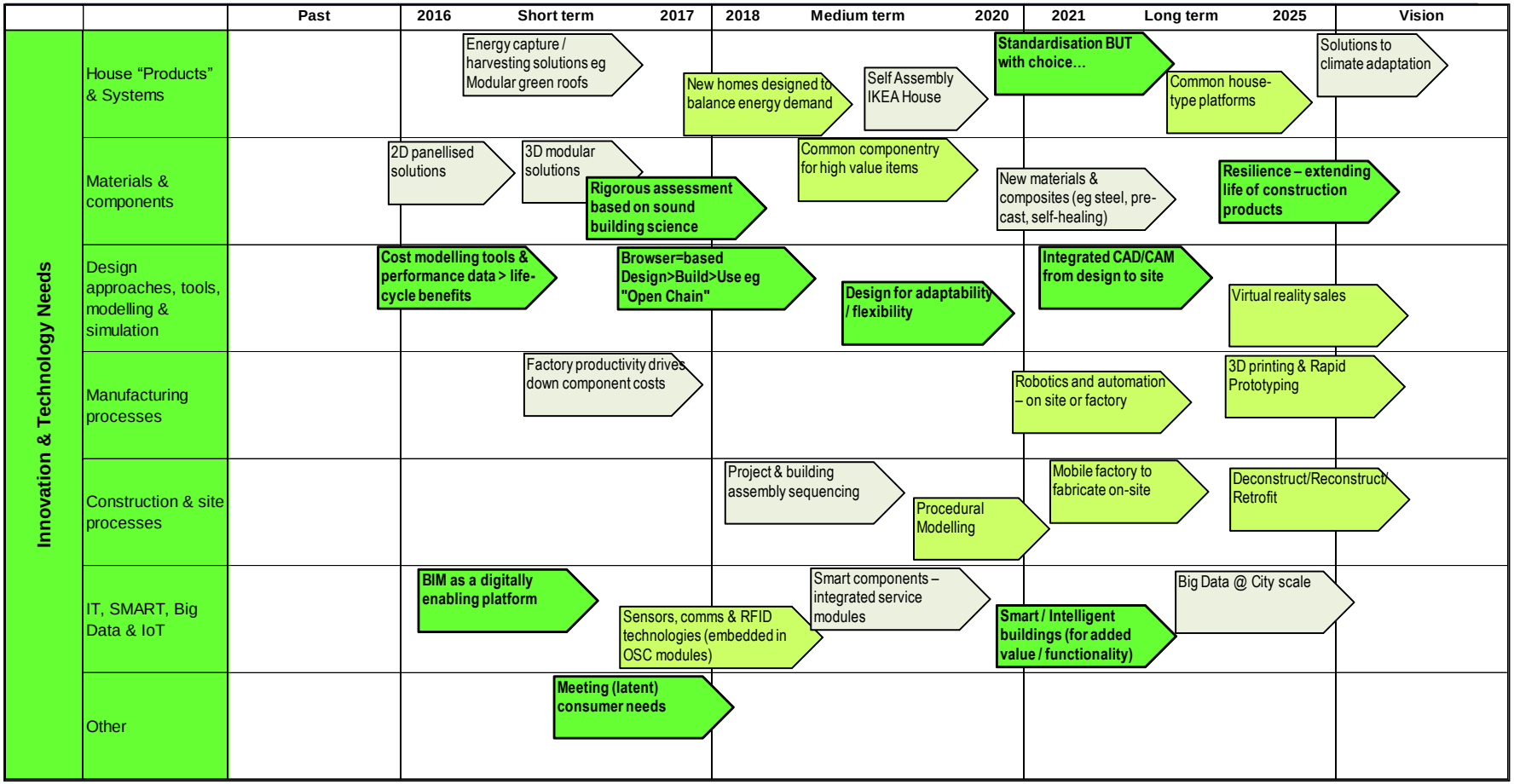
4.1 Innovation & Technology Needs



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4.2 Innovation & Technology Needs (1 to 20)

Rank	Innovation & Technology Needs	Pre-work	Timescale	Workshop	%
1	Standardisation BUT with choice…	8	l	13	11%
2	Browser=based Design>Build>Use eg "Open Chain"	0	m	13	11%
3	Cost modelling tools & performance data > life-cycle bene	7	s	10	9%
4	Design for adaptability / flexibility	7	m-l	10	9%
5	Rigorous assessment based on sound building science	3	s-m	10	9%
6	Meeting (latent) consumer needs	0	m	7	6%
7	Integrated CAD/CAM from design to site	8	l	7	6%
8	Resilience – extending life of construction products	2	l	7	6%
9	Smart / Intelligent buildings (for added value / functional	7	m	6	5%
10	BIM as a digitally enabling platform	13	s	5	4%
11	Deconstruct/Reconstruct/Retrofit	3	l	5	4%
12	Robotics and automation – on site or factory	7	l	4	4%
13	Common componentry for high value items	3	m	3	3%
14	New homes designed to balance energy demand	5	m-l	2	2%
15	Procedural Modelling	1	l	2	2%
16	Sensors, comms & RFID technologies (embedded in OSC r	8	s-m	2	2%
17	Virtual reality sales	3	l	2	2%
18	3D printing & Rapid Prototyping	6	l	1	1%
19	Common house-type platforms	6	l	1	1%
20	Mobile factory to fabricate on-site	5	l	1	1%

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4.2 Innovation & Technology Needs (cont)

Rank	Innovation & Technology Needs	Pre-work	Timescale	Workshop	%
21	New materials & composites (eg steel, pre-cast, self-heal	8	m-l	1	1%
22	Smart components – integrated service modules	6	m	1	1%
23	Solutions to climate adaptation	1	l	1	1%
24	2D panellised solutions	4	s	0	0%
25	3D modular solutions	5	s-m	0	0%
26	Big Data @ City scale	1	l	0	0%
27	Energy capture / harvesting solutions eg Modular green r	2	m	0	0%
28	Factory productivity drives down component costs	7	s	0	0%
29	Project & building assembly sequencing	2	m	0	0%
30	Self Assembly IKEA House	1	m	0	0%

This chart shows how issues were ranked in voting in the workshop (column: Workshop) and also the initial ranking from participant pre-work (column: pre-work) and the timescale (Short, Medium or Long-term) where the issue is most relevant.

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4.3 Innovation & Technology Linkages

Rank	Innovation & Technology Needs	Need strategic partnerships within supply chain > Lack of collaboration	No demand > passive consumers unaware of MMC inc poor perception of "pre-fab"	Investment needed in MMC suppliers – volume surety & volatility	Lending, valuation & Insurance - Concerns over product durability & equity retention	Immature supply chain (need auto model: component > sub-assembly > building assembly)	Risk-Averse Culture	Fragmented procurement & need for new models	Business case for change – ability to demonstrate benefits	Need better, safer, cleaner, faster etc building at same cost (no just cost down)	Requires economies of scale (lack of standards)	Lack of performance data & running costs for OSM housing	TOTAL
		A	B	C	D	E	F	G	H	I	J	K	
1	BIM as a digitally enabling platform	1		1		1	1	1	1		1	1	8
2	Standardisation BUT with choice…			1	1	1		1	1	1	1		7
3	Integrated CAD/CAM from design to site	1				1		1	1		1		5
4	Factory productivity drives down component costs	1		1		1		1			1		5
5	Cost modelling tools & performance data > life-cycle benefits		1	1		1		1	1				5
6	Robotics and automation – on site or factory			1		1		1		1	1		5
7	Project & building assembly sequencing	1		1		1		1			1		5
8	Sensors, comms & RFID technologies (embedded in OSC modules)		1						1	1	1	1	5
9	Smart / Intelligent buildings (for added value / functionality)				1		1	1			1	1	5
10	New homes designed to balance energy demand		1			1	1			1		1	5
11	3D printing & Rapid Prototyping					1		1		1	1		4
12	Mobile factory to fabricate on-site	1				1				1	1		4
13	Rigorous assessment based on sound building science		1		1			1		1			4
14	Design for adaptability / flexibility						1			1	1		3
15	Common house-type platforms	1		1		1							3
16	Common componentry for high value items	1				1					1		3
17	Resilience – extending life of construction products		1				1					1	3
18	New materials & composites (eg steel, pre-cast, self-healing)						1				1		2
19	Smart components – integrated service modules							1			1		2
20	Virtual reality sales			1		1							2
21	Energy capture / harvesting solutions eg Modular green roofs		1				1						2
22	Deconstruct/Reconstruct/Retrofit				1							1	2
23	3D modular solutions					1							1
24	2D panellised solutions			1									1

This chart shows how key Barriers to MMC adoption can be overcome through Innovation and Technology

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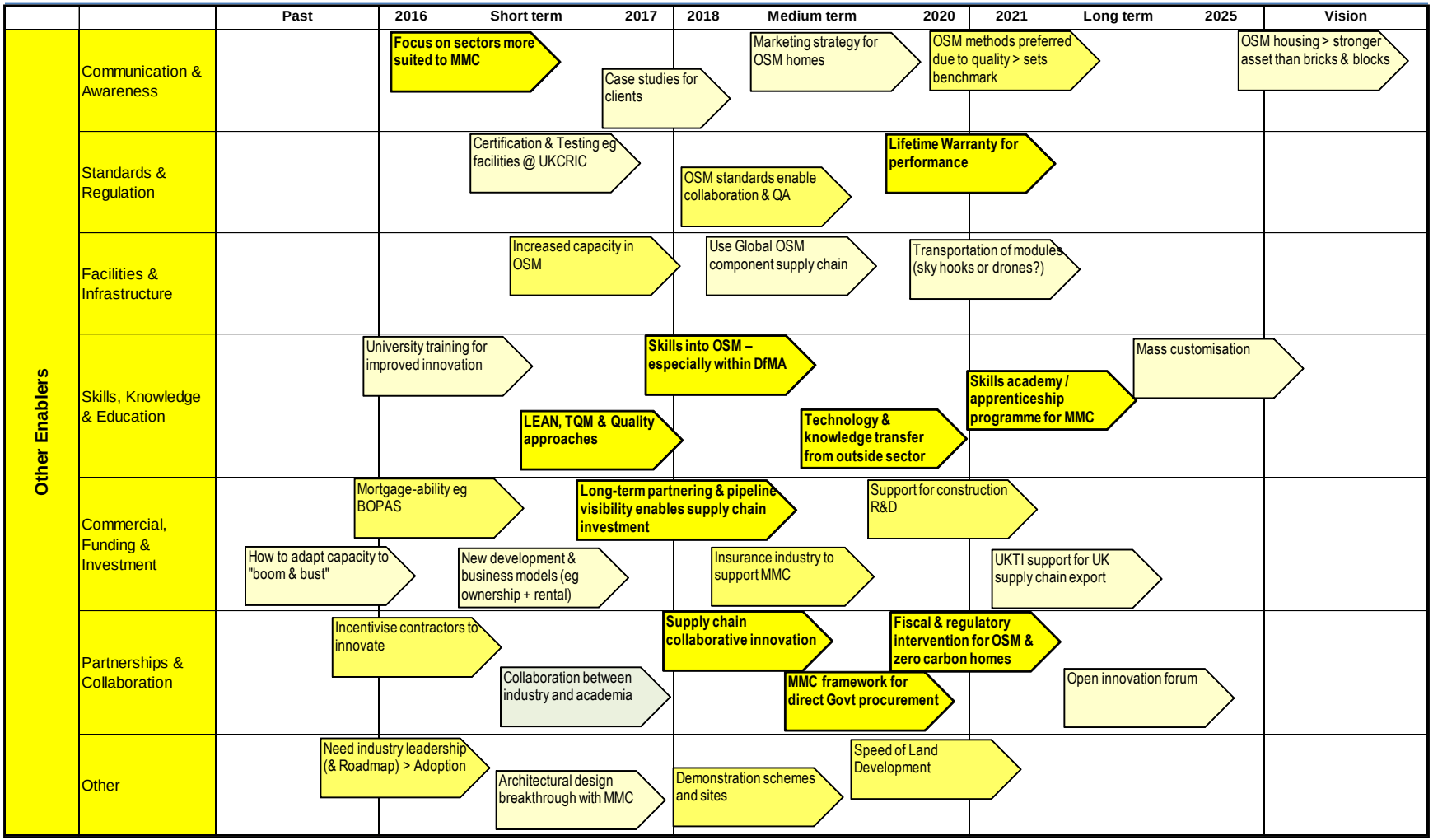
4.4 Enablers



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4.5 Enablers (1 to 20)

Rank	Other Enablers	Pre-work	Timescale	Workshop	%
1	Fiscal & regulatory intervention for OSM & zero carbon homes	8	m-l	12	11%
2	Skills academy / apprenticeship programme for MMC	5	m-l	12	11%
3	Supply chain collaborative innovation	9	m	8	7%
4	Lifetime Warranty for performance	2	m-l	7	6%
5	Technology & knowledge transfer from outside sector	8	m	6	5%
6	MMC framework for direct Govt procurement	1	m	6	5%
7	Focus on sectors more suited to MMC	0	s-m	5	5%
8	Skills into OSM – especially within DfMA	10	s-l	4	4%
9	Long-term partnering & pipeline visibility enables investment	9	m	4	4%
10	LEAN, TQM & Quality approaches	9	s-m	4	4%
11	OSM methods preferred due to quality > sets benchmark	8	m-l	4	4%
12	Demonstration schemes and sites	10	s-m	3	3%
13	Increased capacity in OSM	7	s	3	3%
14	Mortgage-ability eg BOPAS	7	s	3	3%
15	Insurance industry to support MMC	5	m	3	3%
16	Support for construction R&D	4	m	3	3%
17	Need industry leadership (& Roadmap) > Adoption	3	s-m	3	3%
18	Incentivise contractors to innovate	2	s	3	3%
19	Speed of Land Development	0	s-l	3	3%
20	OSM standards enable collaboration & QA	10	s-m	2	2%

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4.5 Enablers (cont)

Rank	Other Enablers	Pre-work	Timescale	Workshop	%
21	Marketing strategy for OSM homes	5	s-l	2	2%
22	Collaboration between industry and academia	2	s	2	2%
23	Certification & Testing eg facilities @ UKCRIC	2	s-m	2	2%
24	Mass customisation	0	m	2	2%
25	OSM housing > stronger asset than bricks & blocks	5	v	1	1%
26	New development & business models (eg ownership + re	5	s	1	1%
27	UKTI support for UK supply chain export	4	l	1	1%
28	Case studies for clients	4	m	1	1%
29	University training for improved innovation	0	m	1	1%
30	Use Global OSM component supply chain	3	m	0	0%
31	Transportation of modules (sky hooks or drones?)	2	s-l	0	0%
32	Architectural design breakthrough with MMC	1	s	0	0%
33	How to adapt capacity to "boom & bust"	1	s	0	0%
34	Open innovation forum	0	m	0	0%

This chart shows how issues were ranked in voting in the workshop (column: Workshop) and also the initial ranking from participant pre-work (column: pre-work) and the timescale (Short, Medium or Long-term) where the issue is most relevant.

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4.6 Enabler Linkages

Rank	Other Enablers	Need strategic partnerships within supply chain > Lack of collaboration	No demand > passive consumers unaware of MMC inc poor perception of "pre-fab"	Investment needed in MMC suppliers – volume surety & volatility	Lending, valuation & Insurance - Concerns over product durability & equity retention	Immature supply chain (need auto model: component > sub-assembly > building assembly)	Risk-Averse Culture	Fragmented procurement & need for new models	Business case for change – ability to demonstrate benefits	Need better, safer, cleaner, faster etc building at same cost (no just cost down)	Requires economies of scale (lack of standards)	Lack of performance data & running costs for OSM housing	TOTAL
		A	B	C	D	E	F	G	H	I	J	K	
1	Supply chain collaborative innovation	1	1			1	1	1	1	1	1		8
2	Demonstration schemes and sites			1		1	1	1	1	1	1	1	8
3	Insurance industry to support MMC	1	1	1	1	1	1			1		1	8
4	Support for construction R&D	1	1		1	1		1		1	1	1	8
5	Long-term partnering & pipeline visibility enables supply chain inve	1		1			1	1	1		1		6
6	New development & business models (eg ownership + rental)	1	1	1		1				1	1		6
7	Technology & knowledge transfer from outside sector	1				1	1	1			1	1	6
8	Case studies for clients	1	1	1				1	1			1	6
9	OSM standards enable collaboration & QA			1	1	1		1			1		5
10	Mortgage-ability eg BOPAS	1	1	1			1					1	5
11	Use Global OSM component supply chain			1		1		1			1	1	5
12	OSM methods preferred due to quality > sets benchmark	1	1							1	1		4
13	Skills into OSM – especially within DfMA					1		1			1		3
14	LEAN, TQM & Quality approaches	1				1					1		3
15	Increased capacity in OSM					1			1		1		3
16	Need industry leadership (& Roadmap) > Adoption		1					1				1	3
17	OSM housing > stronger asset than bricks & blocks					1	1						2
18	Skills academy / apprenticeship programme for MMC									1	1		2
19	Marketing strategy for OSM homes				1					1			2
20	UKTI support for UK supply chain export						1	1					2
21	Fiscal & regulatory intervention for OSM & zero carbon homes		1										1

This chart shows how key Barriers to MMC adoption can be overcome through Other Enablers

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5. Detailed exploration of Barriers to Adoption and Solutions (explored in breakout groups)

Team	Barriers	Workshop	Team			
A	Need strategic partnerships within supply chain > Lack of collaboration	27	ON	AH	JL	
B	No demand > passive consumers unaware of MMC inc poor perception of "pre-fab"	20	CS	TM	GB	
C	Investment needed in MMC suppliers – volume surety & volatility	18	AL	SC	KW	SD
D	Lending, valuation & Insurance - Concerns over product durability & equity retention	15	MJ	DM	MD	NW
E	Immature supply chain (need auto model: component > sub-assembly > building assembly)	14	MC	NR	RB	JG
F	Risk-Averse Culture	13	PD	JG	GH	
G	Fragmented procurement & need for new models	12	AW	SM	PC	
H	Business case for change – ability to demonstrate benefits	9	JS	IB	TH	IP
I	Need better, safer, cleaner, faster etc building at same cost (not just cost down)	9	RB	NE	TF	
J	Requires economies of scale (lack of standards)	8	NB	SA		
K	Lack of performance data & running costs for OSM housing	7	SG	MG	RS	

Note: The Barrier of lack of skills in the sector ranked 11th overall, but was not explored in a breakout group as it is already the subject of a separate CLC workstream, and cuts across all remaining barriers.

See over for outputs from breakout group exploration of Key Barriers to Adoption.

Key: Black text – original team input

Red text and  – carousel group comments

 - Carousel – "Agreement"

 - Carousel – "Disagreement"

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5.1 Barrier A: Need strategic partnerships within supply chain > Lack of collaboration

Elevator Pitch: We need to be open and understand each other's drivers, because we've recognized that a lot of us don't understand each other, and we can't really collaborate if we don't understand what's driving us. We need to share learning and look to other more sophisticated industries for knowledge transfer. I think one of the things we've discussed is we do a lot of collaboration as individual companies in individual ways. There isn't a set template or set approach.

Key innovations we will need include the development of a platform around how we measure and monitor buildings; and then to establish how we collaborate, and develop a set way to do this. We also need a consistency in approach in partnering and openness in that approach.

Enablers for success include obviously time, resources and organizational cultural shift. What we're lacking is really lessons learned from others, and the sharing of case studies between those.

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Team: A	A key Barrier to deployment of MMC is: **Needs strategic partnership with supply chain.**	Timescale to Solution:
Issues that need to be resolved to overcome this barrier:	• Trust, Openness, Honesty • Commitment • Lack of know-how of each other models • Be prepared and do…. • New relationships into existing business models.	**Key Solutions to overcome this barrier are:** • **Be open and understand each other drivers, share learning and look to other more sophisticated/industrialised sectors.** • **Incentives to share**
Solutions to overcome this barrier:	• Real & transparent success stories • Bite size chunks of solutions • Carefully agree with partners. • Do at scale partnership based project. • Pick people you get on with..	These solutions will Deliver: increased supply of housing 4; quality and performance 3.5; environ-mental performance 1.5; adaptation to climate 1.5
Innovation and Technology Needs	• Speed if delivery programme • Technology & advancement • Cost/Value • Quality & assurance • Skill agnostic solution	**Key Innovation and Technology Needs would be:** • **Develop correct platforms for:** **- quality,** **- cost/value,** **- speed,** **- certainty.** • **Consistency of approach in partnering (openness).** • **Role of top 10 house builder CEO's ?**
Fit with Current UK Capability: Current (Deployed / in dev't)	• Early strategic partners • Individual structure of partnership by client • SMEs not doing… Lack of "Certainty"	
Fit with Current UK Capability: Gaps => Innovation Needs	• Consistency of approach by partner • Appropriate innovation & measure of performance/value • World-class strategic partnership structures	
ENABLERS Communication & Awareness Standards & Regulation Facilities & Infrastructure Skills & Education Finance & Investment Partnerships & Collaboration	• Communication & Awareness • Skills & Education • Partnerships & Collaboration	**Enablers for Success:** • **Time & resource,** • **organizational cultural fit.** • **Learn from what has not worked.**
Knowledge Gaps & Next Steps in validation / evaluation: • Lack of lessons learned and adoption of "best in-class" principles		**Volunteers to move this forward:** • **ON** • **AH** • **NB**

Team A	2016 Short term 2017	2018 Medium term 2020	2021 Long term 2025
What Will Success Look Like	1 million COST EFFICIENT houses. Delivered using more efficient processes + technology through partnership		
Owners, Clients & Occupiers	What is being done, by who & with what success !!	Agree Approach & template !!	Pilot & deliver project to support. Use new method to deliver project. Use new method to service client, const, architect. Link to client to enable strategic partnership. Ensure their policies + Regl allow partnership+ ?
Construction companies			
Materials & Systems suppliers			
Architects, QS & Engineers			Learn Adapt Redo
Planners & Regulators			Roll out
Other			
Knowledge Transfer from outside sector	How do other do it ? Better		HCA/CA
Government (Policy & Investment)	Market Research Funding	Develop Platform	Funding or Land to Test.

5.2 Barrier B: No demand > passive consumers unaware of MMC inc poor perception of "pre-fab"

Elevator Pitch: We were faced with the challenge of no demand or passive consumers, and how to overcome that lethargy. We ended up with a map that said: “We should agree an MPG measure, something which is a simple set of data that we can collect, share, educate, campaign, have a driver of improving standards as a backdrop, and as a consequence of that, increase the demand for better performing buildings.”
We thought that the success would look like energy efficiency literacy in consumers, because at the moment they don’t have the language or the ability to talk about it. Demand for higher performance standards from the buildings that they are procuring, and this higher performance attracting a premium, so it starts to have a value, and also that it’s taken into account when calculating loans and mortgages. The overall target should be 100 per cent of new homes delivered to have more fabrication or assembly offsite than onsite by 2025.

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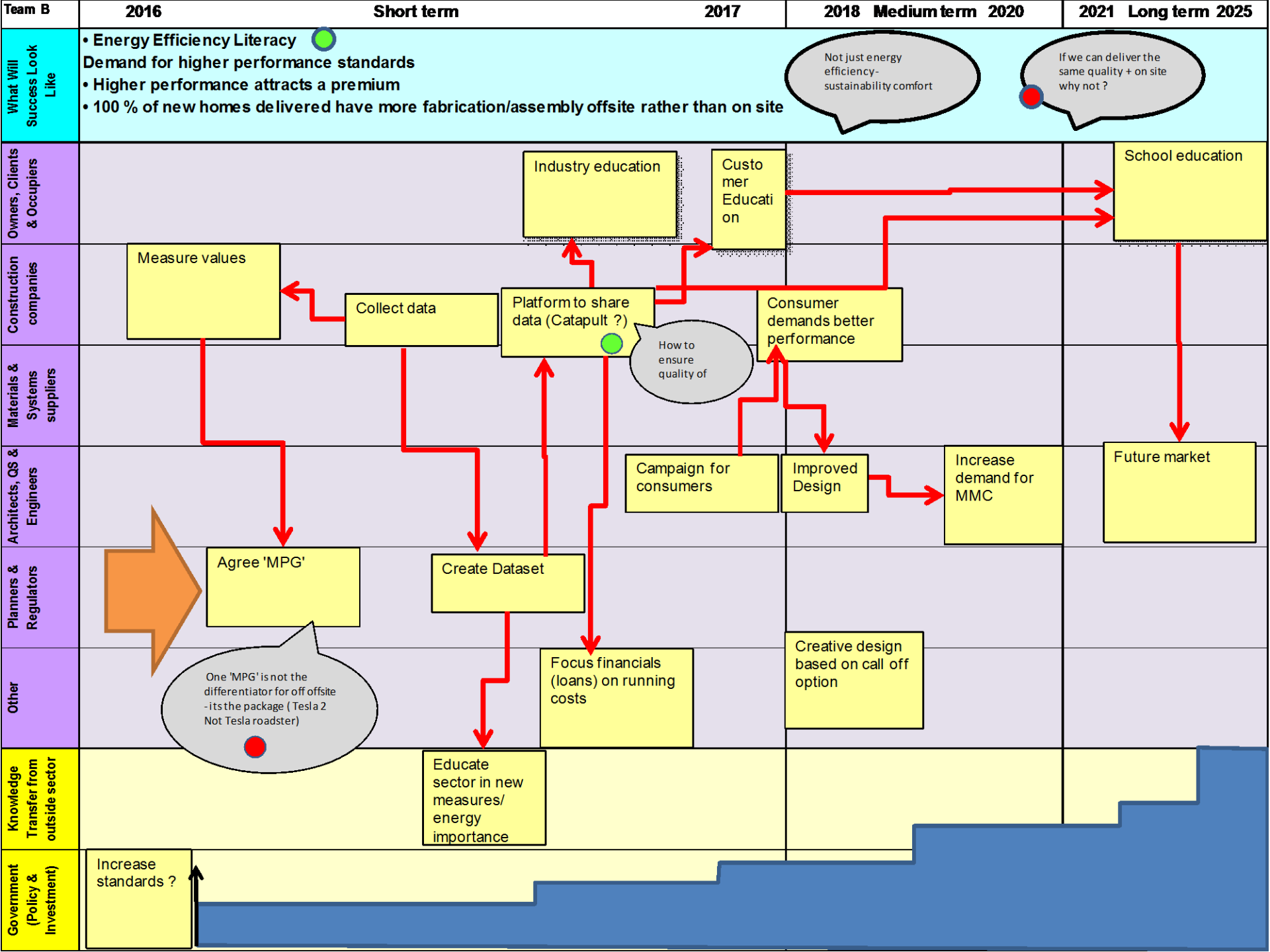
Team: B	A key Barrier to deployment of MMC is: **No demand - passive consumers**	Timescale to Solution: 2years +
Issues that need to be resolved to overcome this barrier:	• Lack of understanding about building performance (No " MPG" measure) • No idea where to start (consumers) • Inability to measure the value of performance • Understanding lifetime costs especially running costs	**Key Solutions to overcome this barrier are:** **• Provide clearly understood performance measures that allow consumers to align performance with value, demonstrate the value of MMC.**
Solutions to overcome this barrier:	• Standardise intutive performance measures • Accessible data/comparative tables (revealing the value of MMC) • Include cost of energy (in new property) as part of loan application • Ever rising standards over a defined period	**These solutions will Deliver:** increased supply of housing: 1 quality and performance: 5 environ-mental performance: 5 adaptation to climate: 3
Innovation and Technology Needs	• New tools for measuring performance • Education/availability of information.	**Key Innovation and Technology Needs would be:** **• Credible** **• Consistent** **• Comparable** **• Measures**
Fit with Current UK Capability — Current (Deployed / in dev't)	• Data exists (Innovate UK/ Energy Cos./ EPCS (SAP)….) • Smart meters + real time data • Does not exist in sufficient quantity?	
Fit with Current UK Capability — Gaps => Innovation Needs	• Actual performance against a standardised approach • BRE doing study on this	
ENABLERS Communication & Awareness Standards & Regulation Facilities & Infrastructure Skills & Education Finance & Investment Partnerships & Collaboration	• Simple messages for consumers • Commitment to ? Up standards • Incroporate energy costs in valuation/loan assement	**Enablers for Success:** **• Empowering consumers to deman better performance (smart client)**
Knowledge Gaps & Next Steps in validation / evaluation: • Lack of lessons learned and adoption of "best in-class" principles		**Volunteers to move this forward:** **• T.M'C.**


Team B
2016
Short term
2017
2018
Medium term
2020
2021
Long term
2025
What Will Success Look Like
• Energy Efficiency Literacy
Demand for higher performance standards
• Higher performance attracts a premium
• 100 % of new homes delivered have more fabrication/assembly offsite rather than on site
Not just energy efficiency- sustainability comfort
If we can deliver the same quality + on site why not ?
Owners, Clients & Occupiers
Construction companies
Materials & Systems suppliers
Architects, QS & Engineers
Planners & Regulators
Other
Knowledge Transfer from outside sector
Government (Policy & Investment)
Industry education
Custo mer Educati on
School education
Measure values
Collect data
Platform to share data (Catapult ?)
How to ensure quality of
Consumer demands better performance
Campaign for consumers
Improved Design
Increase demand for MMC
Future market
Agree 'MPG'
Create Dataset
One 'MPG' is not the differentiator for off offsite - its the package (Tesla 2 Not Tesla roadster)
Focus financials (loans) on running costs
Creative design based on call off option
Educate sector in new measures/ energy importance
Increase standards ?

5.3 Barrier C: Investment needed in MMC suppliers – volume surety & volatility

Elevator Pitch: Our challenge was what are the investments needed for MMC suppliers. The key thing here is demand, and specifically certainty of demand.
In terms of solutions, we focused on three different markets:

1) The government. This is probably a new market in a way, but we want some form of a national housing programme that commits to a demand level, a bankable demand level to enable us to go ahead and make investments.
2) Growth in the Private Rental Sector is a key new market emerging, so the adoption by various organizations of MMC, not just ad-hoc adoption here and there, will drive MMC.
3) The existing markets – If we get 1) and 2) then we believe the rest will follow.

Innovation and technology needs: We need some kind of UK aggregation platform to be able to bring the demand across the UK into some platform that we can then go and tender against. And on the award of certain level of volume the MMC supply chain will be able to make the investments. The development of standardized housing layouts will also help aggregate volume.
In terms of Enablers, then we need the government to continue to support things like grant and R&D funding, to enable us to go ahead and make these investments.

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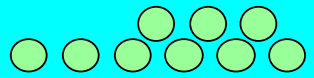
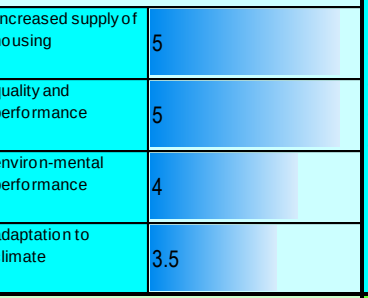
Team: C	A key Barrier to deployment of MMC is: **Investment needed in MMC suppliers**	Timescale to Solution: 12 months (max 5 years)
Issues that need to be resolved to overcome this barrier:	• Certainty of demand (order book, pipeline, 2-5 years) • Access to funds for MMC development (people, skills, facility etc) • Confidence in systems/products in developers/employers • Government pre-contract R+D continued investment " If you build it, we will buy from you" - Do we need certainty of demand or flexibility of supply ?	**Key Solutions to overcome this barrier are:** **• Create new marlets attractive to investors** **• Government national housing programme (volume - 100k !)**
Solutions to overcome this barrier:	• Private sector: long term contract, machine requirements • PRS: adoption of MMC as solution • Government: accelerated demand through national programme. • Committed vloume (not framework)	**• PRS - investors** **• Existing markets - incentives** **• Fiscal - tax ?** **• R+D Skills support grant to offset risk**





Innovation and Technology Needs		• Adavanced manufacturing capacity • Automation & production efficiency • Cultural change programme	**Key Innovation and Technology Needs would be:** **• UK aggregation -platform not easy, ready or considered.** **- Demand platform (like infrastructure plan.)** **• Housing layout, standard designs, pattern book, but allowing Choice!** **• Fiscal interventions-existing (tax)** **• PRS - as a UK wide solution (not hot spots)**
Fit with Current UK Capability	Current (Deployed / in dev't)	• Systems • More standard components integrated • Visulatisation & Configuration for customers • Digital supply chain	
	Gaps => Innovation Needs	& Gaps	

ENABLERS Communication & Awareness Standards & Regulation Facilities & Infrastructure Skills & Education Finance & Investment Partnerships & Collaboration	• Adavanced manufacturing skills • Mortgage support • Bank open funds • Industrialisation Projects • Innovate UK./ AMSCI R+D funding Market stimulation e.g. electric vehicles incentive • Training schools OSM • Nation housing program procurement • Contract to pre-commit to voulme (not framework) • Favourable T+ C's payments • Relationship contracts	**Enablers for Success:** **• A contract to pre-commit to volume - national call off.** **• Government gaurantees - access cash** **• R+D funding** **• Creation of National Housing programme.**

Knowledge Gaps & Next Steps in validation / evaluation: • What are the actual accessible funds ? • What manufacturing technologies would generate a jump in production	**Volunteers to move this forward:** **• AL (LOR)** **• KW** **• SC • SD • RB**

Team C	2016 Short term 2017	2018 Medium term 2020	2021 Long term 2025
What Will Success Look Like	**Demand bankable:** **• Existing P/Dev - 120k units -> +25k plus Self Build - 20k -> + 0k = Total of 140k + 25k** **• National program - 100k 30 % • PRS programme 100k 30 % (140k , 225 k)** **• Supply investment 20 factories = 10k each** **• Global player- OSM homes**		
Owners, Clients & Occupiers	Create pattern books (collaborative) Demand aggregation platform	BOPAS to underpin investment ?	
Construction companies	Develop NHP supply contract	Invest in production capacity	
Materials & Systems suppliers			
Architects, QS & Engineers	Create pattern books (collaborative) Creative design based on call off option Re-engineering the design process - tools - skills Earlier decision making		
Planners & Regulators	Develop NHP contract to pre-commit volume NHP design guide & Design Standard Performance standards for procurement LA. / Council planners Buy-in LA Skilling regulators		
Other	Use of demand platform		
Knowledge Transfer from outside sector	Aerospace type contractor model Engage overseas models		
Government (Policy & Investment)	Decide on national housing programme fiscal support - tax- exist, market		

5.4 Barrier D: Lending, valuation & Insurance - Concerns over product durability & equity retention

Elevator Pitch: The key message here is to achieve and demonstrate product durability and longevity over two time horizons: the first being initial mortgage, and then subsequent mortgages during the life of the building.

We need warranty providers to have the confidence and knowledge to provide warranties that will allow mortgage lenders to say, “Yes, we will accept that,” so it’s automatically mortgage-able. We also need good communication, so that these warranted lifetimes become accepted as standard across all lenders.

In terms of the resale of the property, what happens when a surveyor says, “So what’s this built on?” “We don’t know.” ...So how can we lend on it? To tackle this we need consistency of methodology and approval of systems, and sharing of that information amongst warranty bodies, building control bodies, and insurers. At present this is very fragmented: there’s no one system, one methodology.

We would look to get a position by 2025 where there’s nationally available information on field types of assets. If a surveyor comes along in 30 years’ time, they can find on the web what a property was built of and the approvals its MMC construction carried at the time, so everyone has confidence. Warranty bodies and material systems suppliers operating like this will establish benchmarks and guidance that are widely accepted and help to make innovation the norm.

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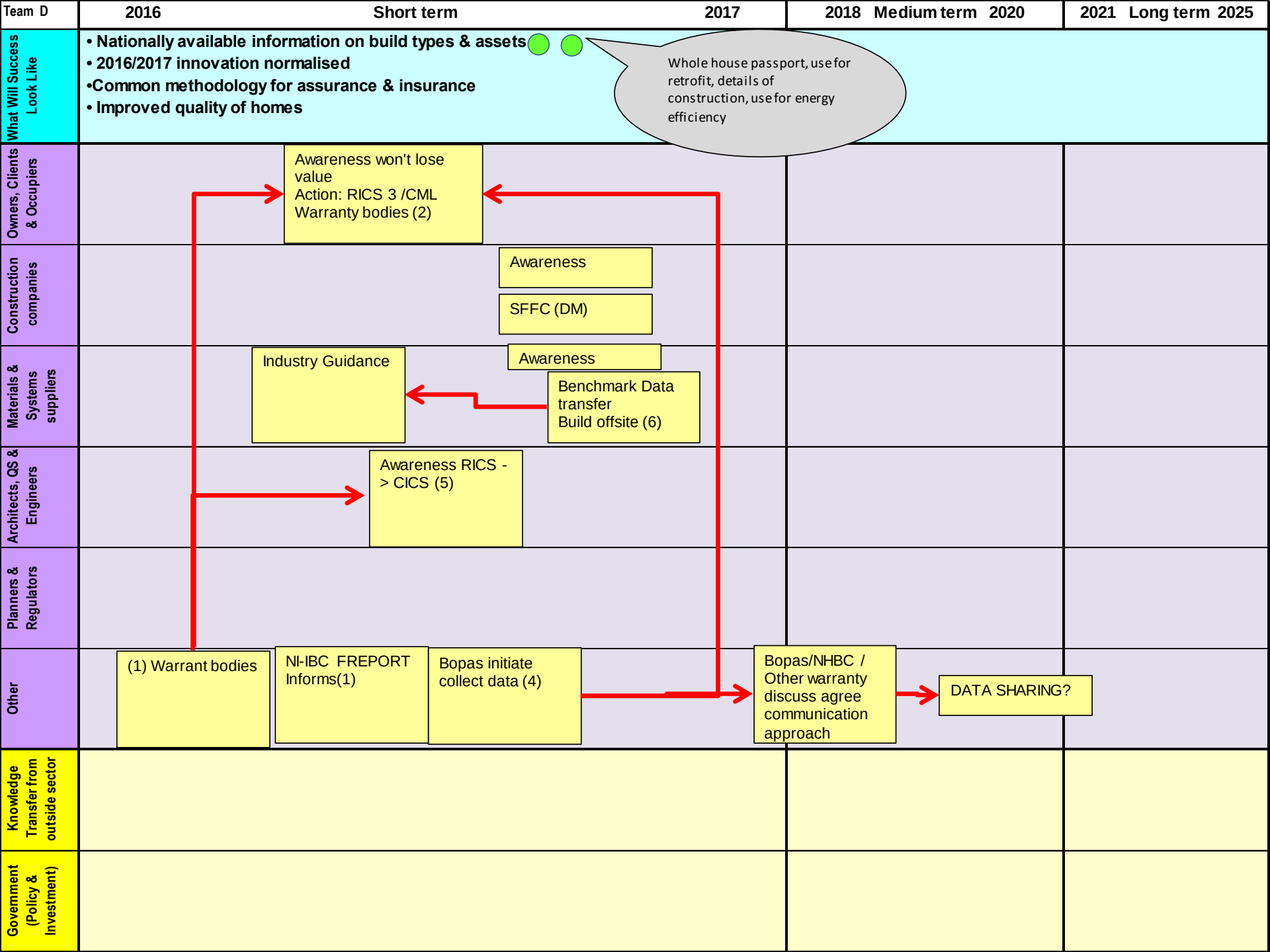
Team: D	A key Barrier to deployment of MMC is: **Lending valuation & insurance**	Timescale to Solution: 1-2 YRS
Issues that need to be resolved to overcome this barrier:	• Generic product-process assurance by competent authority • Over all product (project specific) • Assurance authority recognised by CLM • New doc standards • Costly & Risky	**Key Solutions to overcome this barrier are:** • Readily acesible data set • Common methods for greater acceptance
Solutions to overcome this barrier:	• Verification • Availibility of information > 10 YR (record databses) • Develop guidance on standards	**These solutions will Deliver:** increased supply of housing: 3 quality and performance: 5 environ-mental performance: 4 adaptation to climate: 4
Innovation and Technology Needs	• Development of readily accessible dataset • Move to requirement (? Land Regsitry ?) • Shared common methodology for acceptance	**Key Innovation and Technology Needs would be:** • Database / Logbook (eg Land registry) - Block - Chain Create modern book of the BRE PRE-FAB/NON TRAD Bible NOW!
Fit with Current UK Capability: Current (Deployed / in dev't)	• NHBC home user & guide • BOPAS property register • Premier ?	
Fit with Current UK Capability: Gaps => Innovation Needs	• Not a requirement • No established norm	
ENABLERS Communication & Awareness Standards & Regulation Facilities & Infrastructure Skills & Education Finance & Investment Partnerships & Collaboration	• Move innovation quality to norm -> exemplar & guidance	**Enablers for Success:** • Warrenty bodies need to collabrate. • System suppliers need to collaborate (technology) (LED)
Knowledge Gaps & Next Steps in validation / evaluation:		**Volunteers to move this forward:** • ON • Mark dones NHBC • Nick Waterhouse+A1:K11


Team D
2016
Short term
2017
2018
Medium term
2020
2021
Long term
2025
What Will Success Look Like
• Nationally available information on build types & assets
• 2016/2017 innovation normalised
•Common methodology for assurance & insurance
• Improved quality of homes
Whole house passport, use for retrofit, details of construction, use for energy efficiency
Owners, Clients & Occupiers
Awareness won't lose value
Action: RICS 3 /CML
Warranty bodies (2)
Construction companies
Awareness
SFFC (DM)
Materials & Systems suppliers
Industry Guidance
Awareness
Benchmark Data transfer
Build offsite (6)
Architects, QS & Engineers
Awareness RICS -> CICS (5)
Planners & Regulators
Other
(1) Warrant bodies
NI-IBC FREPORT Informs(1)
Bopas initiate collect data (4)
Bopas/NHBC / Other warranty discuss agree communication approach
DATA SHARING?
Knowledge Transfer from outside sector
Government (Policy & Investment)

5.5 Barrier E: Immature supply chain

Elevator Pitch: How we get a supply chain working to deliver MMC? What would success look like? Industry capable of producing 100,000 homes per annum by 2025, working from between 30 and 50 factories or assembly locations based around the country, depending on the productivity.

To enable that to happen, we need digital tools to standardise a lot of processes. We need to establish an open market so that companies can buy from a range of pre-manufactured assemblies. Then the manufacturers of those assemblies need to in turn buy some components, so you get a digital supply chain / market within which there is clarity. This also requires clarity about performance requirements and so on. We also need innovation around the creation of that type of platform, the data architecture capable of maintaining it, and the use of digital simulation tools for things like logistics, especially how we move large assemblies up and down the country without the current complex red tape .

We also need to borrow knowledge from other industries, eg logistics and aero industries etc. We need continuation of funding, which we think is really quite important at this particular point . Beyond that, much will depend on stable requirements, with large clients in particularly saying, “We’re going to go down this route, so we’ll provide an opportunity of 2,000 units a year for next five years.” That enables people to invest.

SAINT-GOBAIN

Department for Business Innovation & Skills

UNIVERSITY OF CAMBRIDGE

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Team: E	A key Barrier to deployment of MMC is: **Immature Supply Chain**	Timescale to Solution: Five year ?
Issues that need to be resolved to overcome this barrier:	• Standardisation of component or process ? • Sole supplier ? (Risk) • Existing 'old' assets/factories • Skills in sub-assembly +logistics • Using existing manufacturing assets- retooling /repurposing • Lack of standardisation of interfaces •Designing • Virtual interface MET • Sub assembly (BOSHH Car) • Handling eqpt. on-site • Transport logistics + erection logistics determine components size-weights • Multiple markets to satisfy • sale-rental-planning-end user- • Requirement for testing/certification	**Key Solutions to overcome this barrier are:** • **Digital standardisation tools CAD/CAM** • **Product lifecycle management (PLM)** • **Procurement/specification/QMS process** • **Flexible manufacturing** • **Specialist fabrication skills**
Solutions to overcome this barrier:	• Stop changing during construction -> Manage specification • Prefabricated sub assemblies - rooms/frames/ ? • Learn from automotive/ aerospace • Focusing on end use - outcomes - performance • new entrants • Rooms not walls not plasterors • Systems not Products • Flexible manufacturing - close to labour ? materials ? site of build ? • Establishing an MMC supply-chain architecture - product level standard tolerances • Simulation of performance • Sub assembly • On-site sub assembly or factory mobile • Training for a digital industry / skilled assemblers/ trades	**These solutions will Deliver:** increased supply of housing: 1 to 3 quality and performance: 1 to 5 environ-mental performance: 1 to 5 adaptation to climate: 1
		Specialist fabrication skills - To enable the market place to deliver solutions - Why Standardise ?
Innovation and Technology Needs	• Change NS to suit prefabrication - factory production tolerances • Specification control of sub-assembly through BIM from beginning. • Procure late = barrier • Existing trades -> assembly skills • Process flow simulation • Transport logistics • Logistic simulation process	**Key Innovation and Technology Needs would be:** • **Interface design R+D** • **Data architecture** • **BIM L1 ->** • **Simulation (performance, manufcature, construction)**
Fit with Current UK Capability: Current (Deployed / in dev't)	• NBS create, BIM LZ, Mopular factories • 2 D framing • Pods • Systems not products	
Fit with Current UK Capability: Gaps => Innovation Needs	• Transport red tape • Sustainable factory locations • Fabrication system design • Just in-time construction • Joined-up supply chain • Clear data architecture to communication PERT. Req. and manufacturer capability	
ENABLERS Communication & Awareness Standards & Regulation Facilities & Infrastructure Skills & Education Finance & Investment Partnerships & Collaboration	• Industry awareness • Speficiations STDS, Insurance STDS, • Logistics • Apprentice levy-ringfence for MMC • AMSCII funding • AERO / (Auto?) Industry	**Enablers for Success:**
Knowledge Gaps & Next Steps in validation / evaluation: • Prod. Planning for assembly/JIT delivery sequencing • Logistics of sub-assemblies • Testing + quality control /validation		**Volunteers to move this forward:** • NR • AW • Tim Hall • ON

Team E	2016 Short term 2017	2018 Medium term 2020	2021 Long term 2025
What Will Success Look Like	**Industry capable of producing 100k homes P/A. 30-50 factories/assembly locations (depending upon productivity !) could be much fewer.** **Capacity MMC, Productivity, Sub assembly, logistics** Will only work if land bank owners buy in Pop-up factories ? Good to set the ambition - raise the bar		
Owners, Clients & Occupiers	Stable requirements for fixed time frame		
Construction companies	Housing Supply Company Handling equipment for assembly-onsite	On-factory or assembly	Demolition + recycle materials
Materials & Systems suppliers	Process capability data New production capacity Sub-new assembly capacity		
Architects, QS & Engineers	Clear digital definition of design requirements Fill digital model + bom frozen		
Planners & Regulators	Clear + Unchanging requirements		
Other	Insurers standards QMS Definition Logistic Capabilities for sub-assemblies		
Knowledge Transfer from outside sector	Production process management		
Government (Policy & Investment)	Factory setup fund R+D demonstration fund		

5.6 Barrier F: Risk-Averse Culture

Elevator Pitch: Risk aversion stems from a lack of knowledge of what's out there in terms of MMC, and the ability to judge the various technologies in performance merits. We need to be on a learning journey, and to be aware of some history. We're still living with the "60,000 pounds house competition" that was in 2005. If you get it wrong in technology, it lives with you for a long, long time.

Key innovation in technologies would be one of the drivers for a lot of house builders – in order to meet current demand with conventional construction there will be a brick and block skills shortage, so our ability to engage with modern methods of construction, using the ability to deskill existing processes is key to us. To look at the precision associated with the product, lower maintenance, less shrinkage, less water, less waste, better technical performance. They are key things we would look to tap into.

Enablers for success include the ability for the industry to pitch itself to sell benefits to house-builders; at the moment everything we do is trial and tribulation. In some instances the information is not out there readily available, we're having to go through a learning process to understand exactly what the size of the prize is.

What will success look like by 2025? Clearly more houses, if we get this right, and a larger proportion of MMC; happier clients, because we've got greater quality in the build; increased customer satisfaction; and the greater technical performance.

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Team: F

A key Barrier to deployment of MMC is: Risk Adverse culture .

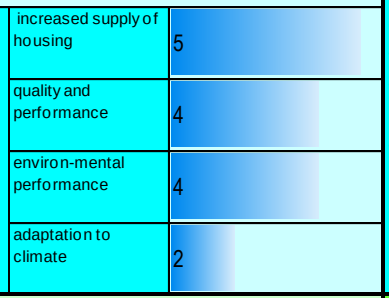
Timescale to Solution:
- Knowledge + Information exchange
- Osmosis trial + testing proven technology

Issues that need to be resolved to overcome this barrier:
- Unfamiliarity -> Learning curve -> risk of managing
- Little incentive to offer new things
- Must be a stated need i.e. people asking for it.
- Innovative companies are often not credible or stable
- No awareness of what's out there + benefits
- Little alignment of innovation + needs of customer
- Where is the win-win ?
- Knowledge of skills required
- People have to live somewhere

Key Solutions to overcome this barrier are:
- **Knowledge of information exchange**
- **Rigrous trials and tests**
- **Technology needs to be proven**
- **Capacity needs to be proven**
- **The ability to compare and constrast the merits of different forms of MMC**
- **A learnign journey**
- **TW - 140,00 houses per year can't afford to get it wrong.**
- **Better alignment of needs + innovation**

Solutions to overcome this barrier:
- Strategic partnerships
- Win-Win-Win Innovation
- Data capture
- Willingness to trial
- Proven benefits

These solutions will Deliver:



Innovation and Technology Needs
- Meaningful benefits to home owner
- Joint up design process

Fit with Current UK Capability

Current (Deployed / in dev't)

Gaps => Innovation Needs
- Grounded context to innovation
- Better availability of innovations

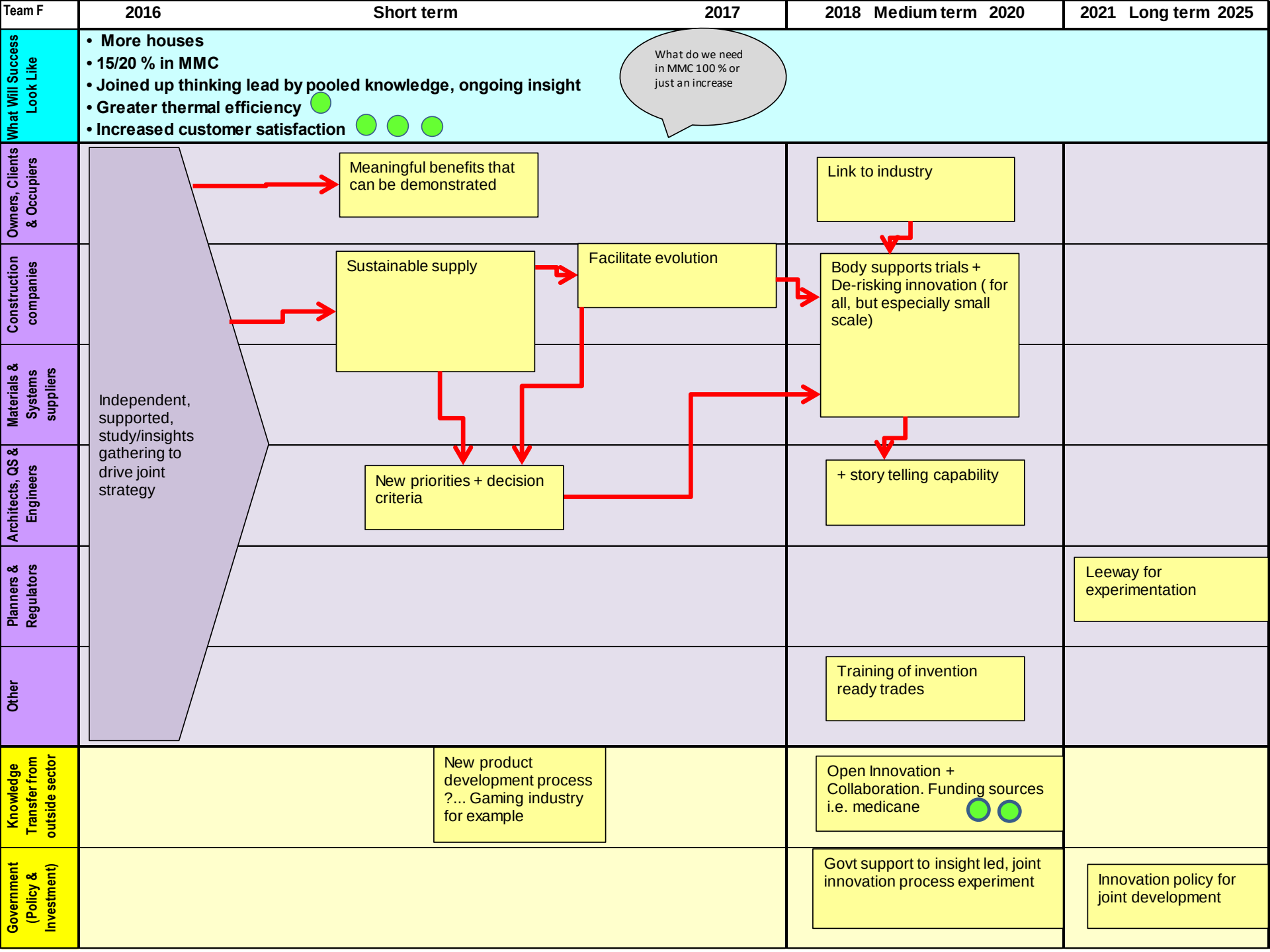
Key Innovation and Technology Needs would be:
- **Innovations to be grounded in reality**
- **Need to understand the merits**
- **Pragmatic & practical.**
- **Need to be able to 'sell' the benefits - sell the " better dream"**
- **Precision, low maintainance, less shrinkage, less waste, less water, better technically- thermal air**
- **Deskill exisiting process**

ENABLERS
Communication & Awareness
Standards & Regulation
Facilities & Infrastructure
Skills & Education
Finance & Investment
Partnerships & Collaboration
- A vehicle to tell innovation stories
- Low maintainance-----Longer life
- Understanding of what is meaningful innovation directions (consumer)
- Iterative experimentation
- Sell the 'better dream'

Enablers for Success:
- Low Maintainance, larger life. Accentuate the positives !
- Sales pitch ! Precision | sustainability
- Derisk the innovation process
- ?, joint insight gathering & story telling
- Real insight into process of innovation commercialisation.
- 'Understanding of innovation experiments.

Knowledge Gaps & Next Steps in validation / evaluation:
- Joint NPD
- Support to the innovator to 'be credible'

Volunteers to move this forward:
- **PD**
- **GJ**


Team F
2016
Short term
2017
2018
Medium term
2020
2021
Long term
2025
What Will Success Look Like
• More houses
• 15/20 % in MMC
• Joined up thinking lead by pooled knowledge, ongoing insight
• Greater thermal efficiency
• Increased customer satisfaction
What do we need in MMC 100 % or just an increase
Owners, Clients & Occupiers
Construction companies
Materials & Systems suppliers
Architects, QS & Engineers
Planners & Regulators
Other
Knowledge Transfer from outside sector
Government (Policy & Investment)
Independent, supported, study/insights gathering to drive joint strategy
Meaningful benefits that can be demonstrated
Sustainable supply
Facilitate evolution
New priorities + decision criteria
Link to industry
Body supports trials + De-risking innovation (for all, but especially small scale)
+ story telling capability
Leeway for experimentation
Training of invention ready trades
New product development process ?... Gaming industry for example
Open Innovation + Collaboration. Funding sources i.e. medicane
Govt support to insight led, joint innovation process experiment
Innovation policy for joint development

5.7 Barrier G: Fragmented procurement & need for new models

Elevator Pitch: We need new models for our procurement, to overcome a lot of "bad behaviours" in the industry. We design things two and a half times, build them one and a half times, and that is not the way we should be working. There's lack of vertical integration, lack of standards for communication, and also a lack of tools, and continually everyone trying to shift risk onto everyone else, and people saying there shouldn't be any risk, not accepting that is a thing we should live with, and we can benefit from.
We need a cloud based platform for procurement and contracting, back to back, start to finish, the whole way through the process: From brief to FM. New smart contracts that can operate within this platform, so we're not having paper, human readable documents, trying to manage what is increasingly a digital process. Re-skilling the workforce, this isn't just people onsite, this is also design teams, understanding that their responsibilities have to change when we use different procurement approaches and contracts. We need a global network of certified providers, operating under similar standards, and with digitally logged feedback, like AirBnB, which allow us to join up the dots in the data with how things are performing.
With our implementation Roadmap we hope by 2020 we'd start to see mainstream uptake, new procurement models and cloud based procurement. And by 2025, this model of doing it cloud based, doing it digital, doing it fully collaborative is industry standard.

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Team: G	A key Barrier to deployment of MMC is: **Fragmented procurement & new models**	Timescale to Solution: 3 YRS (2019)….If we started a group now

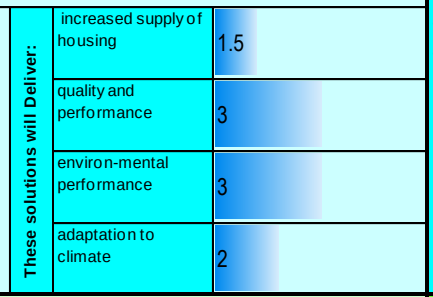
Issues that need to be resolved to overcome this barrier:

1. Lack of vertical integration **2. Hierarchy ?-> contractors->? Sub's**
3. Conflict driven contracts (blame) **4. Brief, design, contract, re-design, manage buildings** **5. Bad behaviours + Dis-connect**
- Momentum to overcome (risk of innovation + industry not experiennced in innovation)
- Procurement purchasing, benefit of long team relationship not seen.
- Industry need to accept some risk
- We build 2.5 times, we build 1.5 times

Solutions to overcome this barrier:

- Professional, technical, information + IP, business models
- Accepting risk is unavoidable
- Agreeing the level which is OK
- Listing, costing, budgeting it
- Sharing rewards
- Deployment budget (using open IP) + R+D budget EG: 90:10 Fix PRJ
- New contracts
- Design Once, Build once !
- Look at other industries + countries (case studies knowledge exchange...)
- Certification warranty, know outcomes predictability.
- Common platforms (Software + Hardware)

(Shaped across industry) (Like car industry)



Key Solutions to overcome this barrier are:
- Cloud based contracting platform (back to back/ start to FM)
- New (smart) contracts + insurance policies
- Re-skilling
- Certified providers/service providers/manufacturers for MMC.

Procurement of Land for housing ?

Innovation and Technology Needs

Fit with Current UK Capability

Current (Deployed / in dev't)
- Fully parametric Platform enabled, digitally fabricatable products
- Collaborative contracts + working standard
- Getting to BIM LVL Z

Gaps => Innovation Needs
- New contracting model + cloud based platform for procurement inc. online payment
- Smart contracts to help with payments
- Digitising the feedback for design team + projects (learn from collaborative economy)

Key Innovation and Technology Needs would be:

Feedback Link

- Joined up data.
- Separation of software + data <- choice of platforms

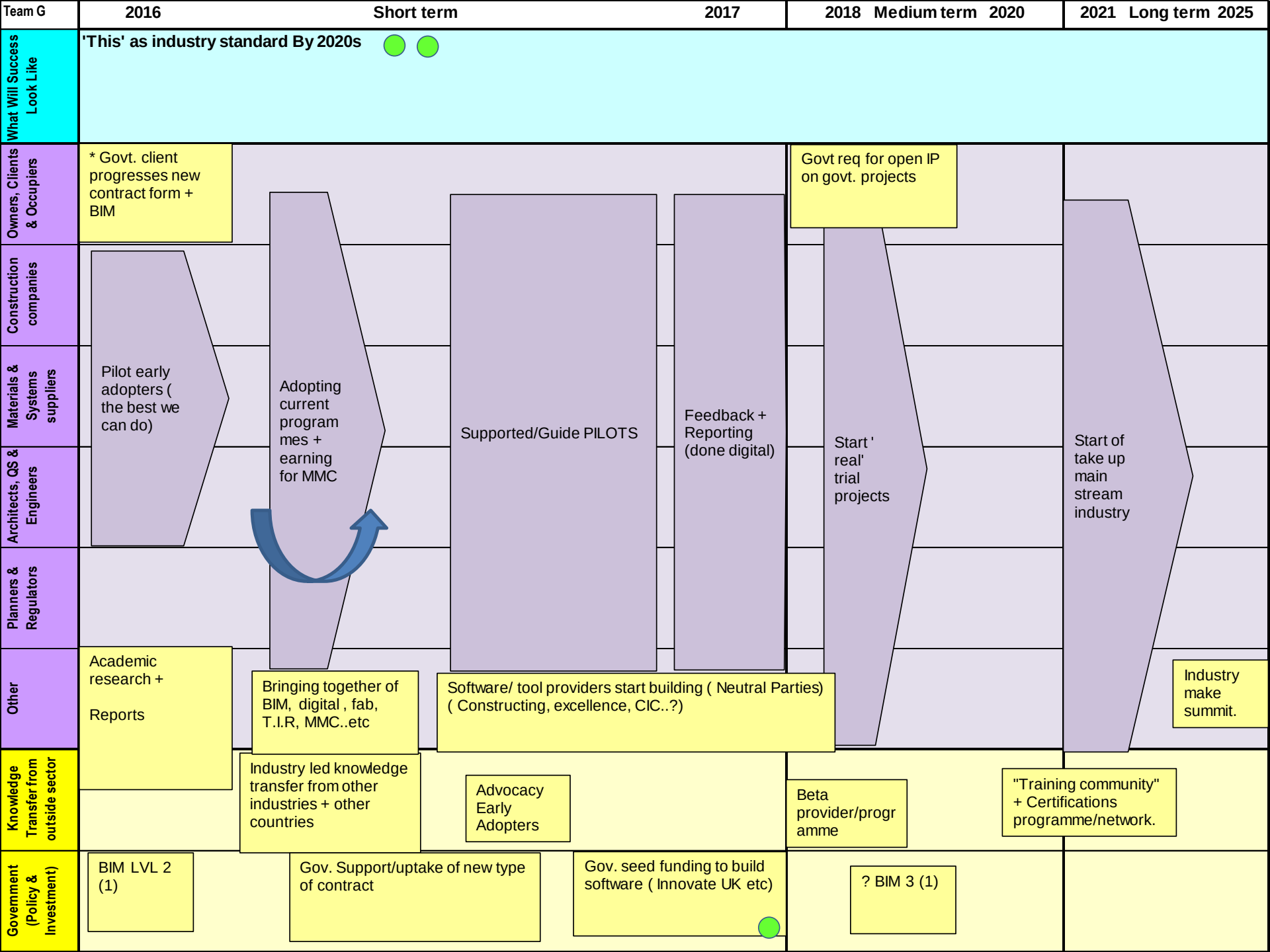
ENABLERS
- Communication & Awareness
- Standards & Regulation
- Facilities & Infrastructure
- Skills & Education
- Finance & Investment
- Partnerships & Collaboration

- " Good news stories"/ trials + PR (Software, procurement finished buildings)
- New procurement types in trials (Inc: other industries + other countries)
- Insurance policies for collaboration
- Re-skilling, " Re-riling" teams.
- To understand the process + other PPL's roles

Enablers for Success:
- **Trials + PR + Review / (Collect data)**
- **White papers/ digestible Reports**
- **Open standards**

Knowledge Gaps & Next Steps in validation / evaluation:
- Too many architects
- No Trades
- Contractors
- Lawyers
- Insurers
- QS
- No clients
- No developers

Volunteers to move this forward:
- **AW**


Team G
2016
Short term
2017
2018
Medium term
2020
2021
Long term
2025
What Will Success Look Like
'This' as industry standard By 2020s
Owners, Clients & Occupiers
Construction companies
Materials & Systems suppliers
Architects, QS & Engineers
Planners & Regulators
Other
Knowledge Transfer from outside sector
Government (Policy & Investment)
* Govt. client progresses new contract form + BIM
Govt req for open IP on govt. projects
Pilot early adopters (the best we can do)
Adopting current program mes + earning for MMC
Supported/Guide PILOTS
Feedback + Reporting (done digital)
Start ' real' trial projects
Start of take up main stream industry
Academic research +
Reports
Bringing together of BIM, digital , fab, T.I.R, MMC..etc
Software/ tool providers start building (Neutral Parties) (Constructing, excellence, CIC..?)
Industry make summit.
Industry led knowledge transfer from other industries + other countries
Advocacy Early Adopters
Beta provider/programme
"Training community" + Certifications programme/network.
BIM LVL 2 (1)
Gov. Support/uptake of new type of contract
Gov. seed funding to build software (Innovate UK etc)
? BIM 3 (1)

5.8 Barrier H: Business case for change – ability to demonstrate benefits

Elevator Pitch: The business case for a change will vary across the variety of different markets that we need to satisfy. We need clarity to get customers in, and there are challenges around a lack of evaluation mechanisms for the whole-life cost of buildings, and the need to incorporate this into regulation. We need to appreciate any threat from non UK solution providers. We need a positive answer to: "Is there a market to invest in?"
Key innovation technology need is to give people accurate data on cost, quality and performance benefits of using MMC, because if you haven't got that, then why would you want to do it? We also have "software" enablers are about encouraging the best solutions and nurturing them to avoid a "VHS versus Betamax" scenario.
We want to take the customer agenda from a dissatisfaction with housing today, all the way through to being happy with the new proposition. The responsibility from the supply chain is to create a compelling vision of what the future looks like. Rather than saying, "That will cost you....", says, "Yes we can, at the same or lower cost."
The Vision is to get to the point where housing is a Fast Moving Consumer Good, as configurable as your phone, your car, or your laptop. The aim is to get flexible homes capacity between 180,000 and 400,000 homes in the UK; turn-off, turn-onable, not a case of, "We're going to make thousands of redundancies, because we no longer need 400,000 homes." It's that flexible adaptable capability, 80 per cent of homes built 80 per cent offsite, value added.

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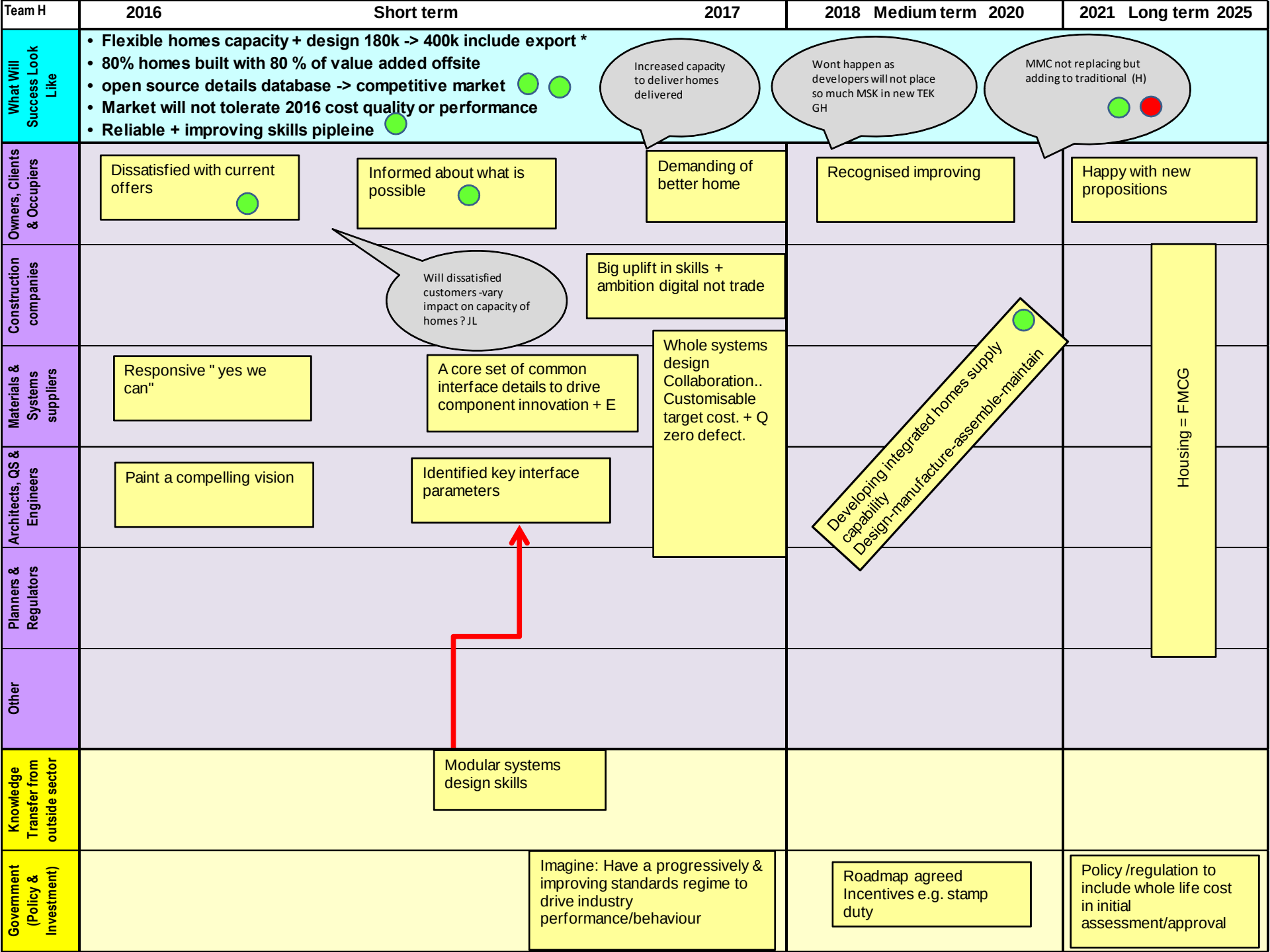
Team: H	A key Barrier to deployment of MMC is: **A Business Case for Change.**				Timescale to Solution: 3-5 Years
Issues that need to be resolved to overcome this barrier:	• What does "the market" want ? (markets) i.e. what problems need to be solved ? E.g. higher quality, quicker delivery What does GOOD look like ? • Which markets ? Housing developers owner- occupies rental market social private and what does value mean ? • Clear who the customer is • Lack of appreciation/valuation mechanisms for while life cost • Historical perception of MMC • Resistance to changing-skills lack of familiarity • Lack of distributed fabrication network (supply chain)				**Key Solutions to overcome this barrier are:** **• Is there a market to invest in**
Solutions to overcome this barrier:	• Demonstration projects/prototypes - all around the country • A chance to kick the tyres • Generate demand • Give investors confidence • Mandate Working Life in £ solutions • Evidence of cost/quality benefits of implementing MMC • Ability to build doster & better or quality project • Continually increasing regulatory standards -Q - CO2 - C-IT-Time-Flex • Big data on building performance	**These solutions will Deliver:**	increased supply of housing	1 in 2016 to 5 in 2025	
			quality and performance	5	
			environ-mental performance	5	
			adaptation to climate	...Later	
Innovation and Technology Needs					**Key Innovation and Technology Needs would be:** **• Accurate data on cost, quality, performance** **Close links with teams B+K**
Fit with Current UK Capability: Current (Deployed / in dev't)	• Scaling + improving existing MMC capacity. • Sensor systems (cheap, easy to deploy - e.g. on your mobile to measure/demonstrate quality)				
Fit with Current UK Capability: Gaps => Innovation Needs	• Tools to accurately assess lifecycle costs • Gathering data to demonstrate performance - apps - sensors -... • Browser based data platform				
ENABLERS Communication & Awareness Standards & Regulation Facilities & Infrastructure Skills & Education Finance & Investment Partnerships & Collaboration	• Demo projects as part of other initiatives e.g. Cambridge Science fortnight • EG (Bicester) Cherwell demonstration village				**Enablers for Success:** **• How do you encourage & nurture the best solutions ? (Betamax vs VHS)**
Knowledge Gaps & Next Steps in validation / evaluation: • What has driven uptake of MMCs in different international markets • Life cycle costs • Market differentiation					**Volunteers to move this forward:** **• IB** **• RB**


Team H
2016
Short term
2017
2018 Medium term 2020
2021 Long term 2025
What Will Success Look Like
• Flexible homes capacity + design 180k -> 400k include export *
• 80% homes built with 80 % of value added offsite
• open source details database -> competitive market
• Market will not tolerate 2016 cost quality or performance
• Reliable + improving skills pipleine
Increased capacity to deliver homes delivered
Wont happen as developers will not place so much MSK in new TEK GH
MMC not replacing but adding to traditional (H)
Owners, Clients & Occupiers
Dissatisfied with current offers
Informed about what is possible
Demanding of better home
Recognised improving
Happy with new propositions
Construction companies
Will dissatisfied customers -vary impact on capacity of homes ? JL
Big uplift in skills + ambition digital not trade
Materials & Systems suppliers
Responsive " yes we can"
A core set of common interface details to drive component innovation + E
Whole systems design Collaboration.. Customisable target cost. + Q zero defect.
Developing integrated homes supply capability
Design-manufacture-assemble-maintain
Housing = FMCG
Architects, QS & Engineers
Paint a compelling vision
Identified key interface parameters
Planners & Regulators
Other
Knowledge Transfer from outside sector
Modular systems design skills
Government (Policy & Investment)
Imagine: Have a progressively & improving standards regime to drive industry performance/behaviour
Roadmap agreed
Incentives e.g. stamp duty
Policy /regulation to include whole life cost in initial assessment/approval

5.9 Barrier I: Need better, safer, cleaner, faster etc building at same cost (not just cost down)

Elevator Pitch: We started off with sort of barrier, and then we've changed it to ensure that MMC is actually going to work. Because fundamentally we got to prove that it's going to be valuable to our market. We looked at the parts around that, and about flexibility, about how we can show that that best value… and that will be cost, but it's best value going forward.

Looking at the different enablers for this: Can we get government to stimulate the process that's going to be able to deliver? Then looking at the Supply Side we talked about risk. How do we make the developers use it? How do we change developers into saying: "Why we are going to build with MMC?" It's less risk, it's better productivity, it's less workforce, and means more profit. Now, we've got to show that to the industry MMC is going to be able to deliver.

Our success picture is that will feed into better quality homes, so at the end of it we get 50 per cent reduction in carbon, and get 50 per cent of our homes built offsite by 2025.

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Team: I	**A key Barrier to deployment of MMC is: To ensue MMC is better, faster, cleaner, greener more building adaptable for same cost then lower**	Timescale to Solution:

Issues that need to be resolved to overcome this barrier:

- Need to create belief
- Need regular flow of demand (volatility is a barrier)
- Lack of skills on site ti deliver cost effectively
- Misconception that these cost more not always the case.
- MMC more expensive than trad (but not always)
- How do we know they are better ? need measures
- Lack of flexibility with MMC
- Lack of continuity + scale to allow investment
- Customisation of standard product difficult/expensive
- Limited ability to supply in small batches or individual
- Costs of transition whilst industry gears up
- Flexible enough so can be drawn down one house at a time

Key Solutions to overcome this barrier are:

- **Prove that MMC represents value for money**
- **Both short term PWS lifetime**
- **Not necessarily cheapest cost !**

Don't rubbish current homes to sell MMC

Solutions to overcome this barrier:

- Pilot project, data published, industry leadership champion
- Industry to contribute to developing courses + sponsor UTC + apprentices
- Supply chain collaboration
- Common incentives for all e.g. R+I funds tax breaks
- Supply chain integration to drive on cost
- Better partnerships customer and supplier
- Demonstrate opex costs = value to asset
- E.g. RSC (Inc) + Bigger developers
- Persuade customers to use MMC which underwrites economies of scale
- Skills-need change of mind set and approach in education
- Thro industry govt college partnerships.
- Convincing customer to pay for better quality
- Engage insurers - pay out if energy performance not met.

These solutions will Deliver:

increased supply of housing	4
quality and performance	5
environ-mental performance	5
adaptation to climate	4

Innovation and Technology Needs

- Need to design for adaptation in future
- Best practice production technology (open source IP?)
- Demonstrate that MMC delivers better quality
- Smart (Inc) houses will provide this data on performance
- Post completion studies that show MMC better
- Need a common testing procedure + standards

Fit with Current UK Capability

Current (Deployed / in dev't)

- Digitisation of customer journey
- Browser based selection and customisation of MMC product

Digitising customer build project is relevant here

Gaps => Innovation Needs

- New technology creates jobs e.g. L+G. to build more houses

Key Innovation and Technology Needs would be:

- **We know delivers superior products**
- **But need to drive down cost**
- **Encourage innovation in supply chain too**

ENABLERS

Communication & Awareness
Standards & Regulation
Facilities & Infrastructure
Skills & Education

- Govt to incentivise MMC sector (e.g. tax breaks)
- Grant funding to support technology transfer + R +I
- Incentives (Inc) short term will drive costs down + business case stacks up.
- Business case -> Govt then regulate
- Strong lobbying voice for MMC
- Consistent demand helped by public sector procurement.

Enablers for Success:

- **Govt (Procurement, Incentives)**

Knowledge Gaps & Next Steps in validation / evaluation:

- How to deliver MMC one house at a time.

Volunteers to move this forward:

- **Tim Hall**
- **NE**
- **RB** • **ON**

Team I	2016 Short term 2017	2018 Medium term 2020	2021 Long term 2025
What Will Success Look Like	• 50% of sector builds using MMC which demonstrates delivery • Better quality - 0 defects - healthier buildings • Greener 50 % less carbon • Faster 50 & quicker (whose process) • More daylight - less chemicals - fresh air ventilation - comfortable space MMC increases capacity to deliver more homes greater Lookingto add to existing production not to reduce it + other sustainability benefits / components etc.		
Owners, Clients & Occupiers	Better Value for money → Happy to pay more if matched by higher value	Longer term want this value for lower cost	
Construction companies	Less Risk; Better productivity; Fewer defects; More profit		
Materials & Systems suppliers	System integration collaborate total supply chain.; Visibility of workload to allow materials suppliers to meet demand		
Architects, QS & Engineers	Good start get them all in same line !; Aligned with client's goals (<-)		
Planners & Regulators			
Other	Measure benchmarks now + monitor -> 2025; Stronger industry voice all aligned		
Knowledge Transfer from outside sector			
Government (Policy & Investment)	Fund demonstration projects; Financial incentives and public procurement; Gov't tax breaks + innovation incentives to stimulate markets; Prove business case+ then regulate		

5.10 Barrier J: Requires economies of scale (lack of standards)

Elevator Pitch: We're looking at economies of scale, and how do we get them quick. And the answer was volume, make more stuff, you get economies of scale. The biggest problem being that normally that's done through standardization, which puts massive constraints on pretty much everything. Our solutions are to first of all create volume via regulation incentives, by getting those with big buying power, buying in. Making specific components which we want to mass produce first, or perhaps mass customise is a better phrase. By integrating parametric design and manufacturing, we can avoid standardization and actually start combining different products into the same manufacturing process, which gives all of those products the same economies of scale as actually making one of them.

Technologically speaking we need parametric design software, which is integrated with machine capability, so we know that we're actually able to manufacture the stuff that we're proposing. And driving manufacturing via CAD software and so you design your "thing" and throw in into machine, and it goes: "Here you go." That requires collaboration between all the stakeholders, consistent demand, and people actually starting to think parametrically rather than fixedly.

Success for us looks like things being cheaper, and being able to customize your components for the same price as standardized things with a 100,000 plus homes built offsite by 2025.

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Team: J	**A key Barrier to deployment of MMC is: Requires economies of scale (adaptive standardisation ?)**	Timescale to Solution:
Issues that need to be resolved to overcome this barrier:	• Lower cost through process/machine optimisation • Parametric design/process • Variation + value with replication (of process/machine) • Components, Design labels, Assemblies rooms • MMC all differs greatly • Maintain reason to innovate (including products) Don't stifle innovation Avoid standardisation Standardise Component Assembly	**Key Solutions to overcome this barrier are:** **• Create volume via regulation/incentives buying power.** **• Select which (high value) components to focus on first.** **• Parametric design + manufacturing (adaptive standardisation)** **Critical aspects need to be standardised E.g. like USB port**
Solutions to overcome this barrier:	• Need scale Volume (regulation/incentives; buying power of big player, govt, procurement clubs) • Decide which components/layouts • Would drive offsite economies of scale. • Feed into manufacturers • Options configrator -> parameters for manufacture. • Brick slips cost more than brick but are 1/5th material ! Why ? • Not bound by current standards based on current buildings.	These solutions will Deliver: increased supply of housing: 5 quality and performance: 2.5 environ-mental performance: 4 adaptation to climate: 1
Innovation and Technology Needs	• Parametric design • Parametric manufacturing • Flexibility	**Key Innovation and Technology Needs would be:** **• Parametric design software with machine capabilities.** **• CAD/BIM driven manufacturing.**
Fit with Current UK Capability: Current (Deployed / in dev't)	• Parametric easier on dimensions - colour, some spec points, components • CAD-CAM -> CNC (In-House/HAL) • Machine constraints to CAD/(HAL) BIM	
Fit with Current UK Capability: Gaps => Innovation Needs		
ENABLERS Communication & Awareness Standards & Regulation Facilities & Infrastructure Skills & Education Finance & Investment Partnerships & Collaboration	• Assume demand being looked at by other group • No-one think offsite design parametric skills - traditional sizes for on-site	**Enablers for Success:** **• Collaboration of key stakeholders.** **• Consistent demand-> higher volume.** **• Parametric thinking** **Consistent demand is luxury. Ask. Walls Ice cream**
Knowledge Gaps & Next Steps in validation / evaluation: • What can B.I.S do to incentivise MMC		**Volunteers to move this forward:** **• SA** **• NR**

Team J	2016 Short term 2017	2018 Medium term 2020	2021 Long term 2025
What Will Success Look Like	• Off-site economies of scale • Custom components for price of standard • Economies of scale for offsite…. not just on-site+manual • 100,000 homes + built offsite Custom buildings, but within a range not infinite variety. Over optimistic ?		
Owners, Clients & Occupiers	Want more homes Buy at volume - demand MMC	Demand smart MMC built homes	
Construction companies	Confidence to invest Collaborate+ decide on key components Embrace digitisation + Parametric design		
Materials & Systems suppliers	Adapt to component/layout decided by construction companies	Parametric manufacturing Manufacture. near/on-site	
Architects, QS & Engineers	Integrate machine constraints in to design Design around offsite not manual		
Planners & Regulators		Automatic validation of variants	
Other	Automotive configurability		
Knowledge Transfer from outside sector			
Government (Policy & Investment)	No negative change in supply needs or standards Incentivisation for MMC		

5.11 Barrier K: Lack of performance data & running costs for OSM housing

Elevator Pitch: The main reason for a lack of performance data is cost; it costs a lot of money to get that data, and to analyse it, so understanding how we process data is really key. Data privacy ownership, who's going to own the data? Is it going to be a construction industry? Or individual homeowners? Looking at business sensitivity, there may be business that don't want the publicity around performance. We also need standardization of data, eg the "MPG type system" mentioned before. Do we need legislation that pushes it forward? Innovation will help drive this with low cost reliable sensors, data privacy, maybe machine learning, so that actually buildings are going to adapt in real-time based on the data they're getting, which will drive wide scale deployment. Sensors will also drive added value, utilizing different financial mechanisms to make this a reality. We need to take the learning and data from the Innovate UK Performance Evaluation Buildings programme into something that can be implemented at much wider scale.

A key enabler is the universal "MPG" standard and associated legislation; probably just one performance indicator that the household has, to allow simple, direct comparison. Who carries the liability for homes that don't perform?

The ultimate goal is hugely ambitious: By 2025, a 100 per cent of new homes with a performance monitoring system in place. It needs to be simple, dynamic, with real-time and historical indicators to enable comparison.

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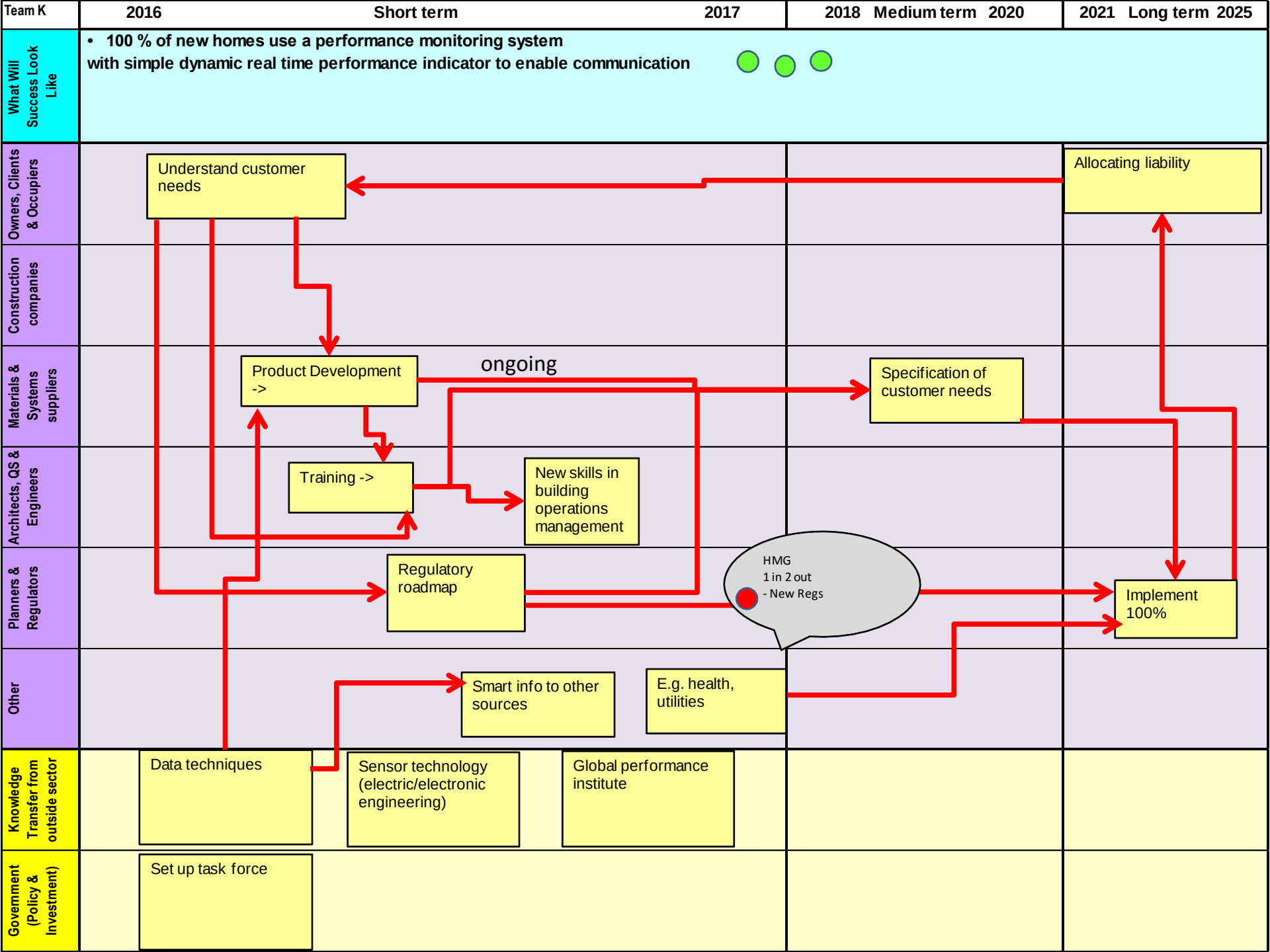
Team: K	**A key Barrier to deployment of MMC is: Lack of performance data**	Timescale to Solution: 2018
Issues that need to be resolved to overcome this barrier:	• Cost-> for collection, processing, data. • Data privacy & ownership of data + trust. • Business Sensitivity • Standardisation of data collection/use • Lack of legislation Close link with team B+H	**Key Solutions to overcome this barrier are:** **• Legislation & universal standard** **All new homes must have real time/historical performance monitor**
Solutions to overcome this barrier:	• Innovation in sensor technology • Universal standard/legislation • Simple direct comparable data • Culture change through wanting • Performance driven competitive advantage • Allocating liability	These solutions will Deliver: increased supply of housing: 1 quality and performance: 5 environ-mental performance: 5 adaptation to climate: 4
Innovation and Technology Needs	• Low cost reliable sensors with long life • Data processing & security • Data visualisation development - user interacts • New machine learning algorithm to optimise control/efficiency	**Key Innovation and Technology Needs would be:** **• Low cost reliable sensor technolog** Cost/Speed & Quality data key.
Fit with Current UK Capability: Current (Deployed / in dev't)	• Significant knowledge in other sectors	
Fit with Current UK Capability: Gaps => Innovation Needs	• Human factors-social behaviour (Change Research) Low cost sensors	
ENABLERS Communication & Awareness Standards & Regulation Facilities & Infrastructure Skills & Education Finance & Investment Partnerships & Collaboration	• Performance evaluation • Legislation • Standards • Real time in-use rating • Installation training Housing forum home performance labelling project! • Innovate UK performance evaluation of building programme. •	**Enablers for Success:** **• The performance data drives time market for quality**
Knowledge Gaps & Next Steps in validation / evaluation: • What data, how much data, social science, end user need. • Need wide scale demonstration		**Volunteers to move this forward:** **• MG • ON CIBSE** **• RB • SC • RSE**


Team K
2016
Short term
2017
2018
Medium term
2020
2021
Long term
2025
What Will Success Look Like
• 100 % of new homes use a performance monitoring system with simple dynamic real time performance indicator to enable communication
Owners, Clients & Occupiers
Construction companies
Materials & Systems suppliers
Architects, QS & Engineers
Planners & Regulators
Other
Knowledge Transfer from outside sector
Government (Policy & Investment)
Understand customer needs
Allocating liability
Product Development ->
ongoing
Specification of customer needs
Training ->
New skills in building operations management
Regulatory roadmap
HMG
1 in 2 out
- New Regs
Implement 100%
Smart info to other sources
E.g. health, utilities
Data techniques
Sensor technology (electric/electronic engineering)
Global performance institute
Set up task force

Appendices

A. Participants
B. Workshop Feedback
C. Landscape Detailed Comments
D. Workshop Process
E. Post-workshop feedback
F. Participant Perspectives

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Appendix A: Workshop Participants

PARTICIPANT	ORGANISATION
Mr Sebastian Andraos	HAL Robotics Ltd
Mr Nigel Banks	Keepmoat
Mr Gilbert Barron	BIS
Ms Irena Bauman	Bauman Lyons Architects
Mr Ron Beattie	Beattie Passive
Mr Rory Bergin	HTA Design
Mr Andy Bradsky von	The Housing Forum
Mr Peter Caplehorn	Construction Products Association
Mr Mike Chaldecott	Saint-Gobain
Mr Simon Cross	BRE
Mr Paul D'Arcy	Saint-Gobain
Mr Martin Davis	IPI Ltd
Mr Stewart Delgarno	Stewart Milne
Mr Nick Ebbs	Blueprint
Mr Thomas Faulkner	Skanska
Mr Mark Gillott	University of Nottingham
Ms Shelagh Grant	The Housing Forum
Mr John Grainham	Taylor Wimpey
Mr Guy Hale	Hadley Steel Framing
Mr Tim Hall	Total Flow

PARTICIPANT	ORGANISATION
Mr Andy Higson	Saint-Gobain
Mr Mark Jones	NHBC
Ms Jade Lewis	Saint-Gobain
Mr Adam Locke	Laing O'Rourke
Mr Sam Markey	Cabinet Office
Mr Shaun McCarthy	Offsite Manufacturing School
Mr Trudie McCormick	Keepmoat
Ms Diana Montgomery	Construction Products Association
Mr Oliver Novakovic	Barratts
Mr Alistair O'Reilly	Laing O'Rourke
Mr Ian Pannell	Buildoffsite
Mr Neil Rawlinson	The MTC (Part of High Value Manufacturing Catapult)
Dr Jennifer Schooling	Cambridge University
Mr Roger Singleton Escofet	Engineering and Physical Sciences Research Council (EPSRC)
Mr Chris Slezakowski	SIG
Mr Alex Whitcroft	Wikihouse
Mr Kieran White	Vision Modular
Mr Finlay White	Modcell
Professor Nicholas Whitehouse	Oxford Brooks University

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Appendix B. Post-workshop Feedback

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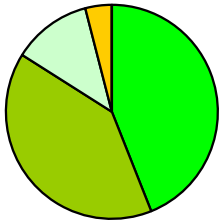
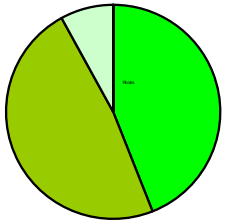
Appendix B. Post-workshop Feedback

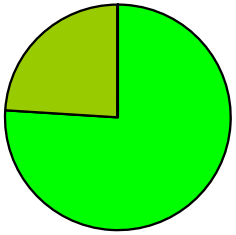
Joining instructions and pre-workshop information



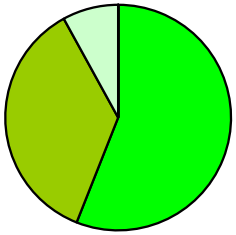
Opening remarks and introduction to the workshop



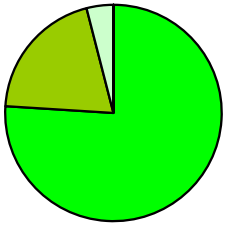
Facilitation of the workshop



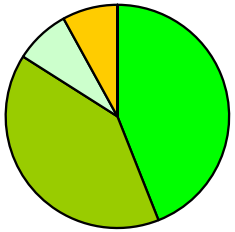
Structure / process of the workshop



Opportunity to participate and contribute



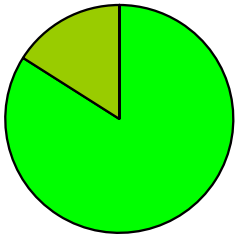
Make-up of workshop participants



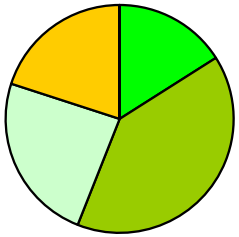
98%

Excellent, VG or Good (excl venue & catering)

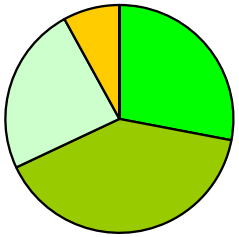
Time keeping



Catering



Venue



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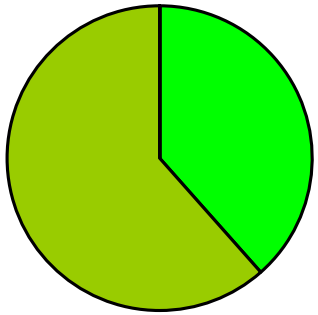
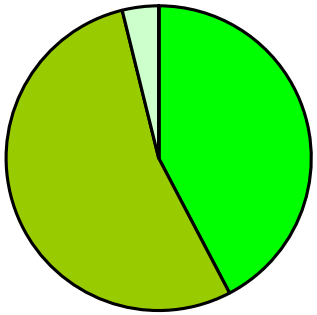
Appendix B. Post-workshop Feedback

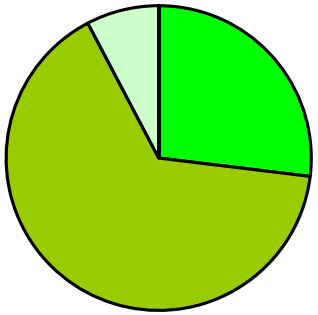
I found the workshop stimulating



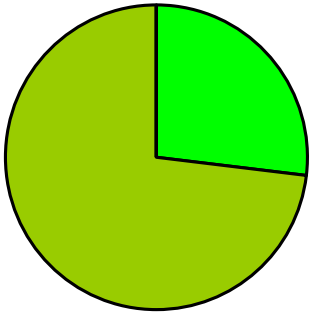
I enjoyed the workshop



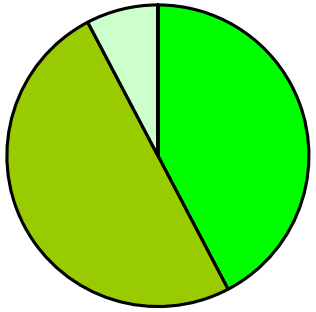
I found my participation worthwhile

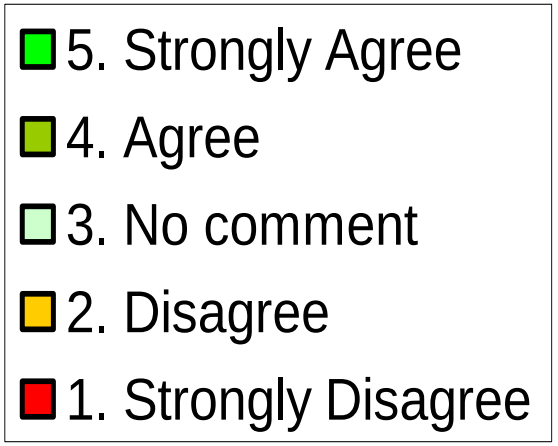


I feel I have contributed to the workshop



The workshop provides useful insights





96%
Strongly agree or Agree

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Appendix B. Post-workshop Feedback

Process & Facilitation	• Introductory keynote set up meeting well • Facilitation was well explained and to pace • Time keeping was kept perfectly • All very clear and concise • Absolutely fantastic facilitation and pace • Excellent structure • Great format – very interactive • Very well organised • Great process to gather a large amount of intelligence • Be sure to capture which didn't score highly, but maybe clues to future
Participant make-up	• Excellent group of participants • Amazing cross-section of industry • Would be nice to have someone from another sector eg Google • Participant make-up heavily biased towards MMC manufacturers
Workshop experience	• Great buzz in the room • Very open participation • Everyone participated well • Very worthwhile
Outputs	• Heard some really new and good ideas • Very good – lots of energy in the room and masses of views • No major surprises but some interesting insights • Industry keeps going around same loop – hopefully this will be different • Very good indeed

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Appendix C. Landscape Detailed Comments

- Barriers
- Innovation
- Enablers
- General

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Appendix C. Landscape Detailed Comments (Barriers)

Barriers	Supporting comment
Immature supply chain (need auto model: component > sub-assembly > bu	• Lack of mature distributed fabrication network to challenge dinosaur centralised manufacturing
Trade skills shortage	• Lack of skill in cost modelling and contract planning to demonstrate time/cost/quality benefits of MMC
Requires economies of scale (lack of standards)	• Fragmentation of demand/volume need to shoe continutiy to allow investment. Strategic relationships • Economies of scale not standardisation • Cost vs Traditional lack of economics of scale • Cost capacity fragmentation
Need better, safer, cleaner, faster etc building at same cost	• Not playing to advantages - current NMC offering not good enough. Better, smarter, efficient, original • TESLA effect - make MMC/comfort 'sexy'
Lack of client support - Need to generate educated client/owner preference for engineered solution	
No demand > Consumers unaware of innovation/MMC	• Lack of understanding across the sector of what innovation allows (BIM/Robotics/Sensors/IOT) prevents adoption of these • Lack of demand due to lack of awareness • Lack of customer awareness of benefits/options • Lack of industry appeitite espeically small house builders due to lack of experience with MMC and lack of understanding of benefits/perceived threat. Build demo porjects (e.g. BRE innovation pool so that people can observe MMC methods and solutions
Investment needed in MMC suppliers – volume surety & return/payback	• Market making. Substantial investment by Government
Risk-Averse Culture	• Risk-averse, conserative culture with no burning platform or client demand
Lending, valuation & Insurance - Concerns over product durability & equit	• valuation • Informed valuation process - Mortgage
Need strategic partnerships within supply chain > Lack of collaboration	• Reluctance to collaborate across the value chain: design, client, contract, logistics, assemble, FM • Lack of seamless, collaborative, agile supply chain. Lack of: accurate info, software tools, contracts and collaboration standards, open IP and business model innovation. • Lack of strategic partnerships driving economies of scale to give standardisation with 'choice' harmonised through OSM components • Lack of supply chain integration
Fragmented procurement & need for new models	• Procurement staff not aligned to success criterea • Fragmented components, uncertainty of delivery. Supply security • Organisations not trusting fragmentation. New way retricts investment • Procurement methods/approaches
Low consumer trust in new tech (brought about by failure?)	• Confidence in the solution/form of construction. Home providers and consumers *private, instituation, PRS, HAs
Lack of performance data & running costs for OSM housing	• MMC all things to all people. Database of MMC/platform. Relative performances: cost, capacity, methodology, sustainablility, tech performance, labour requirements, what is out there mortgage availability
Need industry leadership (& Roadmap) > Adoption	• Lack of a clear business case for change which would trigger industry and Government leadership and collaboration throughout the value chain
Home owner has no voice in specification outside self-build	• The people who care the most (home owner) are disconnected from the industry of house building • Private purchaser/user lack of influence
Visibility & volatility of demand	• Irregular demand • Lack of a clear, long-term investable pipeline of work • Key barrier to MMC: lack of visibility of potential orders. The need to every provider to search out every opportunity because of lack of market trace • Market volatility . Making investment in manufacturing. land availability
Lack of standardisation	• Biggest barrier - no agreed view on standards (floorplan, kitchen. Bathroom, doorsets, windows) • Standardisation > crap design (serial reproduction/not responsive local context)
Cost-only comparisons	• Greater opportunity for integrated systems for energy generation and storage • Develop user-friendly carbon neutral ?? With healthy home • Net zero - all electric homes at nil upfront cost • Destruction of spec based on uneducated cost comparison against MMC that does not site prelim reduction • Cost - if it is not cheaper, then not happy

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Appendix C. Landscape Detailed Comments (Innovation)

Innovation & Technology Needs	Supporting comment
New materials & composites (eg steel, pre-cast, self-healing)	• Adoption of more effective/resilient materials, better performance (energy/sustainability/self healing/low carbon)
Integrated CAD/CAM from design to site	• Digitally enabled supply chain, production processes and in-house management • Integration CAD/CAM design - site • Realistic adoption of digital end of building • Effective use of digital construction to help enable OFMA • Digitisation beyond CAD into quality and lifecycle
Resilience – extending life of construction products	• Extending the life - total value across life
Standardisation BUT with choice…	• If ony MMC could offer more individual customization and choice
Design for adaptability / flexibility	• Lifetime extension - greater long term value • Adaptable contruction design: reconfigure, replace, repair, re-purpose, school becomes carehome in 2W
Meeting Consumer Needs	• Meeting stated and latent needs as a factor for competition
	• MPG equivalent for the energy cost of a building
Open Exchange/Wiki House browser based	• Open chain ™: browser based, design/build/use platform, collaborative, parametric, product/system + service ecosystem • Investment in browser based platform for construction product for integration and collaboration of supply chain • Use browser based platforms to enable customers to make choices (embrace digital) • Browser based platform for user customization and feedback loop • Open source and shared technology
Cost modelling tools & performance data > life-cycle benefits and data	• Performance data • Open source housing, real performance, evidence based: speed, cost, enviornmental performance • Standardised performance rating data e.g. fabric, energy, orientation, infrastruture, adaptability, recyclabililty, CO2 • Advnaced parametric modelling tools that make design and development easy • Publish performance data for all homes • Time/cost/quality/evidence + modelling tools and/or advisory service
BIM as a digitally enabling platform	• PIM with ban on specifications • Industry wide, agreed set of standard components/interfaces (BIM - compatible). This will enable a marketplace
Robotics and automation – on site or factory	• Robots and adaptive automation on and offsite and legilsation to allow it.
Rigorous assessment based on sound building science	•Rigourous and standardised technical assessment/approval (based on sound building science and experience that builds confidence in the solutions/form of construction) • Incentive to build to a hiigher standard, cutting costs etc. but tested • Speed of testing new product for warranty
Common componentry for high value items	•Simple MMC technology that can be delivered by all on site. Testing every home • Common components wnsure reslience and cost competitio. Need volume and long term orders pipeline

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Appendix C. Landscape Detailed Comments (Enablers)

Other Enablers	Supporting comment
OSM standards enable collaboration & QA	• Catalyze innovation around critical standards e.g USB
Need industry leadership (& Roadmap) > Adoption	• Clear industry and government leadership: publish business case, pilot to offer proof, roadmap to adoption • Industry leadership embracing MMC
	• Clients demand and expect high performing homes and share performance data
New development & business models (eg ownership + rental)	• Contract and business model to incentivise collaborative working •Collaborative quality based contract models. Not conflict based contracts. Quality delivery is everyone's responsibility •New development and business models e.g. ownership and rent •Create distinct business framework for MMC operations to play in
Supply chain collaborative innovation	• Effectively digitised supply chain for collaboration and communication • Fully joined up and collaborative sector tech/good practice/management/customer service • No silver bullet! Greater stakeholder collaboration • Hub and spoke collaboration
Mass customisation	• Enablers for mass customization and scale
	• Focus effort on sectors more suited to MMC e.g. institutional investors, PRS, RSL. To add to supply not replace existing supply
MMC framework for direct Govt procurement	• Government call/competition for strategic alliances with insurance companies (X homes per annum)
Support for construction R&D	• Kick starting: make innovation funding stream available from Innovate UK for MMC projects/R&D • Research and innovation funding to drive development of digital engineering and automation
Mortgage-ability eg BOPAS	• Lender confidence/finance • Quality/performance MMS prompts insurance/mortgage preference/discounts
Fiscal & regulatory intervention for OSM & zero carbon homes	• Market stimulation pathfinder contracts for pipeline/volume. Incentives e.g. electric car support • Affordable and social housing 20,000 per year with > MMC • 2025 targets a requirement for public procurement >50 time, 33% costs, 50% sustain, 50% VA • Biggest solution national/local direct commission 10 year house building pipline => 100k per year of standardised but customized homes
Open innovation forum	• Open nnovation forum linked to R&D, business model, product and design prototyping
Demonstration schemes and sites	• Pilot schemes and great PR for MMC. To fuel industry and public interest and comfort
	• Public facing innovation demonstration centre/builds across the country for new innovations (MMC products etc.)
Speed of Land Development	• Speed up land evelopment process - forward visiblity of land availability
Long-term partnering & pipeline visibility enables supply chain investmen	• Strategic partnerships offering strategi partnerships not part • Major client offtake agreements (uderwrite Capex investment) • Long term partnering and pipeline visibility. Confidence for R&D to drive innovation. Delivers increase inn 'value' and 'certainty' • Increase supply certainty by unlicking land availability. New financial models.
Skills into OSM – especially within DfMA	• University training = immproved innovation. • Skills and awareness: design and spec; manufacture and process, install and commission, sign off and assurance
Technology & knowledge transfer from outside sector	• Use automotive world class manufacturing tools/methods • Process and technology from outside sector • Collabroation with other sectors in use of systems management data (e.g. Google, IBM, Microsoft) to help the adoption of this in construction
	• Wording of 'purpose' aim to improve capacity and use of innovation should be by 'innovation', should not be a manufacturer lead objective - should not be self-satisfying

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Appendix C. Landscape Detailed Comments (General)

•MMC product needs to be capable of adaption over lifetime of home. They last a long time! NE
•Custom build needs to make customer journey easy. Digital is solution. Need browser based platforms that offer house products that can be customised and factory ordered. NE
•As a developer I am concerned that MMC often more expensive. MMC produces standardised product, not readily adaptable to allow local response to context. NE
•I want to buy basic "chassis" which I can adapt. NE
•People want choice. Custom built approach can offer choice. To succeed needs smart "kit" homes that can be bought one at a time and customised. NE
•Enable customisation of standardisation.
•Long term trajectories on standards to #enable investment.
•Interoperable "full stack" building systems. #Enabler
•Wiki House open chain platform – customer facing? Look into this.
•Contractual models than encourage collaboration not risk shifting (e.g. for Heathrow T5) #Enabler
•Competition to incentivise strategic parliament - with Government backed insurance cover? #Enabler.
•Transaction costs are crippling adoption. – TH
•Manufacturing not good at coping with boom and bust market. TH
•It's not all MMC or nothing – continuum. DM – TH
•Uncertainty of demand – curtails investment. AL – TH
•Make MMC invisible behind market aesthetic. GH – TH.
•A good manufacturing capability can cope with variable demand. E.g. Walls Ice cream. TH
•People don't care how we make homes. Good output and outcomes needed. JS – TH
•Reputation is easier to lose than earn, (1 bad project kills a brand)?
•Zero defect mentality not quality by inspection.
•Develop the business case for multi tiers – Higher quality, safer, less CO2, Faster.
•Sustainable is not more expensive.
•Custom built vs. configure to order. Very different cost??
•Need clarity of requirements. Design for manufacturing, zero CO2, 2 week build, flexible space. TH
•Housing is NOT a single market. NW – TH
•Vision. Market focus is LTG, more for the same or less. Collaboration, standardise – USB – scale. Transparency – stored IP. Behaviour.
•Supply chain immaturity
•Buyers don't care how we build.
•Prototyping.

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Appendix C. Landscape Detailed Comments (General)

- Workforce attitudes to change, quality etc. Training programmes, skills academy – Make it a source of pride. SL
- Driving down cost base. Might still allow for increased profit margins!
- Skills gap – retirement/loss of workers. Lack of MMC appropriate skills in workforce. Recruit from other industries e.g. steel, manufacturing??? SM
- Totex thinking and valuation needed.
- Business case for change. Trade skills. Collaboration
- Ubiquitous standardised “connectors” (e.g. USB) needed. #Enablers
- What do customers want? – Attractive, good quality build, smart/sensors, healthy? # BIM #Demand
- Assumption that offsite is definitely better, what do people want
- Sole focus on efficiency and cost reduction devalues the trades and construction
- Wording of purpose not increase percentage of new buildings, focus is on increasing overall output
- Technology adoption - approach to adoption is vital, no quick win
- Do small things, tell big stories
- Markets don't change markets, people change markets
- At least four subsectors must be treated differently e.g. PRS, institutional, invsetors, spec build
- Condition wants and needs. People can’t articulate what they want, they have only ever seen the 'standard'
- Learn from the past e.g. 60k home challenge, fit for purpose, minimum 60 year design life
- More user friendly BIM software/interface to enable wider adaption.

Do MMC homes require difference QA tests? What? When?

- Modular/MMC as enabler of resilience/adaptability
- Domestic air quality – driver? #Demand
- NB: Excessive defects no longer an acceptable reality – role of social media/reputation??
- Procurement – models/guidance which promotes conservative choices? #Barriers
- Trad: Decline in DIY culture – “Users just expect things to work”/ plug and play? #Driver
- TW + Barratt + Keepmpat… L&G… Collaborate on key components that are important for offsite??
- Better surfacing of lifetime costs – running, extending, decommissioning, #Enabler
- 2015 Engage with Apple, Samsung, Huawei, etc on smart tech???

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Appendix D. Workshop Process & Templates

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Background & Aims of workshop

Purpose

This workshop will help develop a strategic roadmap of barriers to take-up and commercialisation of Modern Methods of Construction (MMC), and develop solutions to help increase the percentage of new buildings built using, substantially, MMC. The aim is to improve productivity, capacity and the use of innovation in the housing sector by removing barriers to progress and helping the industry to move the new methods from development through to actual commercial use and thereby increase housing supply.

Scope

- Focussing on homes, but with a view to expanding to consider all building types later, and predominantly new build rather than retrofit of buildings.
- Innovative solutions to address increased supply of housing; quality and performance; environmental performance; and adaptation to climate, will all be considered.
- Includes SMART technologies where this will help to improve productivity.

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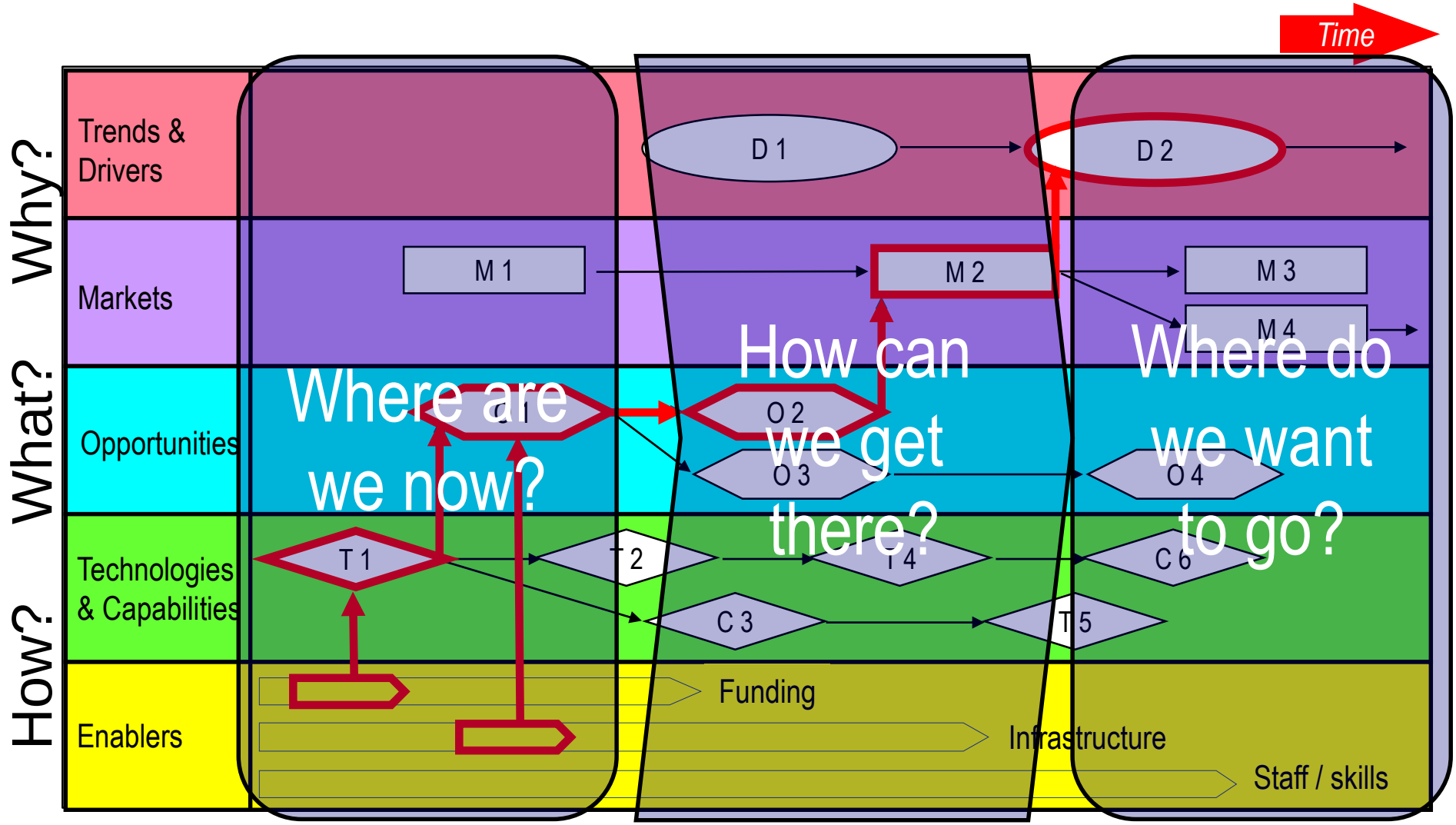
Roadmapping- Linking future to present



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2-Step Workshop process

Step 1: Scan (‘Landscape’)
- Large group activity
- Broad scope
- Share and capture perspectives
- Link, focus and prioritise

Step 2: Probe (‘Landmark’)
- Small group activity
- Focused scope
- Share and capture expertise
- Organise, plan and action

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		Past	2016	**Short**	2017	2018	**Medium**	2020	2020	**Long**	2025	**Vision**
External Drivers	Social		**External Drivers** ➔ *What is shaping the future context and environment for adoption of MMC in UK*									VISION
	Technological											
	Environmental											
	Economic											
	Political and Legal											
Value Chain Perspectives	Owners, Clients & Occupiers		**Value Chain Needs** ➔ *Changing perspectives of all stakeholders and influencers in sector*									
	Construction companies											
	Materials & Systems suppliers											
	Architects, QS & Engineers											
	Planners & Regulators											
	Other											
Barriers to MMC Adoption	Consumer demand & perception		**Barriers to MMC Adoption**									
	Awareness and experience											
	Skills & best practice											
	Cost & commercial											
	Supply-chain											
	Other											
Innovation & Technology Needs	House “Products” & Systems		**Innovation & Technology Needs**: *that will be required to meet the key Barriers to MMC Adoption*									
	Materials & components											
	Design tools, modelling & simulation											
	Manufacturing processes											
	Construction & site processes											
	SMART, Big Data & IoT											
	Other											
Other Enablers	Communication & Awareness		**Other Enablers** *and resources also necessary for success*									
	Standards & Regulation											
	Facilities & Infrastructure											
	Skills & Education											
	Finance & Investment											
	Partnership & Collaboration											

Agenda

Morning	
9:30	Registration & Coffee
10:00	Introduction, agenda and process
10:15	Participants share perspectives by presenting pre-work (max 2 mins each)
11:15	Prioritise Drivers and Stakeholder Needs
11:30	Break
11:45	Identify key Barriers to Implementation
12:30	Lunch
Afternoon	
13:15	Identify breakout groups for Afternoon Session
13:30	Explore Priority Barriers to develop potential Solutions
14:15	Develop outline Action Plan
15:00	Break
15:15	Present Solution and Action plan back to plenary, and review
16:00	Close

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Appendix E. Post-workshop feedback

- For the executive summary of barriers I think that the difference between (traditional procurement and traditional contracting), compared to (prefabrication procurement and prefabrication contracting) leads clients to think that they cannot change from their traditional procurement model, and in fact, many of their procurement professionals seem to be telling them so. This is a serious barrier to progress. So some guidance for clients on how to procure offsite buildings within EU rules, including case studies would be helpful.
- I also think that a proliferation of similar but slightly different technologies is not helpful. For example, each modular manufacturer choosing to construct buildings from similar but slightly different systems, leaving clients with the risk that if there is problem with one manufacturer they cannot easily procure the remainder from another.
- On the social drivers I think that it's worth mentioning that the general reversal of buying and renting behaviour in favour of urban living is a strong determinant for the increase in urban population.
- I think that it's also mentioning, in the context of Tata, that factories can go where there a people to work in them, particularly skilled people. So supporting this industry will bring dividends in social stability, bringing post-industrial areas out of worklessness and so on.

- My biggest concern which I voiced on the day, is that the methodology you used to identify the areas of biggest consent does not recognize the more disruptive ideas presented such as distributed manufacture and KE between sectors. The danger of this is that we put forward bad recommendation for land supply to a few large manufacturers who will then go bust as soon as the supply/demand dries out. We are in the danger of completely missing he point that we are now at the threshold of DISRUPTIVE technologies which will move off-site into a its true potential through of distributed digital fabrication- this is a game changer for the off-site industry and yet that does not, at the moment, feature in your report.
- Also the carbon agenda is much greater driver then speed of erection- again your chosen methodology distorts this- it important for the policy makers to really understand this as they are not currently maximising the potential of off-site methods to help meet the carbon reduction targets- these are set to rise in line with the rise of housing shortage.

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