

LIGHTWEIGHT MATERIALS IN TRANSPORTATION



AVM056D
September 2015

Andrew McWilliams
Project Analyst

ISBN: 1-62296-149-8



BCC Research
49 Walnut Park, Building 2
Wellesley, MA 02481 USA
866-285-7215 (toll-free within the USA),
or (+1) 781-489-7301
www.bccresearch.com
information@bccresearch.com

TABLE OF CONTENTS

TOPIC	PAGE NO.
CHAPTER 1 INTRODUCTION	2
BACKGROUND	2
STUDY GOALS AND OBJECTIVES	2
INTENDED AUDIENCE	3
SCOPE OF REPORT	3
INFORMATION SOURCES AND METHODOLOGY	4
ANALYST'S CREDENTIALS	4
RELATED BCC RESEARCH REPORTS	4
BCC RESEARCH WEBSITE	5
DISCLAIMER	5
CHAPTER 2 EXECUTIVE SUMMARY	7
<i>SUMMARY TABLE GLOBAL MARKET FOR LIGHTWEIGHT MATERIALS IN TRANSPORTATION, THROUGH 2020</i>	7
<i>SUMMARY FIGURE GLOBAL MARKET FOR LIGHTWEIGHT MATERIALS IN TRANSPORTATION, 2014-2020 (MILLION TONS/\$ MILLIONS)</i>	7
CHAPTER 3 OVERVIEW	10
DEFINITIONS	10
LIGHTWEIGHT MATERIALS	10
TRANSPORTATION EQUIPMENT	10
IMPORTANCE OF LIGHTWEIGHT MATERIALS	10
FUEL CONSUMPTION IN THE TRANSPORT SECTOR	10
<i>FIGURE 1 TRANSPORTATION SECTOR SHARE OF GLOBAL LIQUID FUELS CONSUMPTION, 2012 AND 2035 (%)</i>	10
<i>FIGURE 2 GLOBAL FUEL CONSUMPTION BY TRANSPORT MODE, 2014 (%)</i>	11
TRANSPORT SECTOR CONTRIBUTION TO GREENHOUSE GASES AND OTHER EMISSIONS	12
Greenhouse Gases	12
<i>FIGURE 3 GLOBAL TRANSPORT SECTOR CONTRIBUTION TO GREENHOUSE GAS EMISSIONS, 2014 (%)</i>	13
Other Emissions	14
ROLE OF LIGHTWEIGHT MATERIALS IN REDUCING TRANSPORT ENERGY CONSUMPTION AND EMISSIONS	14
TRADE-OFFS	14
Safety Aspects of Lightweight Materials	14
Cost	15
<i>FIGURE 4 COMPARATIVE COST/STRENGTH OF STEEL VERSUS LIGHTWEIGHT MATERIALS FOR VEHICLE PRIMARY STRUCTURES (\$/LB AND GPA)</i>	16
Durability/Reliability	17
Recyclability	17
Conservatism	19
END-USER SEGMENTS	19
<i>TABLE 1 GLOBAL CONSUMPTION FOR TRANSPORTATION EQUIPMENT MATERIALS BY SEGMENT, THROUGH 2020 (MILLION TONS)</i>	19
<i>FIGURE 5 GLOBAL CONSUMPTION FOR TRANSPORTATION EQUIPMENT MATERIALS BY SEGMENT, 2014-2020 (MILLION TONS)</i>	20

TOPIC	PAGE NO.
<i>FIGURE 6 GLOBAL CONSUMPTION SHARE FOR TRANSPORTATION EQUIPMENT MATERIALS BY SEGMENT, 2014 VERSUS 2020 (%)</i>	20
MOTOR VEHICLES	22
Historical Production	22
<i>FIGURE 7 GLOBAL PRODUCTION SHARE FOR MOTOR VEHICLES BY TYPE, 2014 (%)</i>	22
Future Production	22
<i>TABLE 2 PROJECTED MOTOR VEHICLE PRODUCTION BY TYPE, THROUGH 2020 (MILLION UNITS)</i>	23
<i>FIGURE 8 PROJECTED MOTOR VEHICLE PRODUCTION BY TYPE, 2014-2020 (MILLION UNITS)</i>	23
Vehicle Weight and Materials Use	23
<i>FIGURE 9 AVERAGE VEHICLE WEIGHTS BY CLASS, 2014 (LBS.)</i>	23
<i>FIGURE 10 TOTAL MOTOR VEHICLE MATERIAL USAGE, 2014-2020 (MILLION TONS)</i>	24
RAILWAY LOCOMOTIVES AND ROLLING STOCK	25
Historical Production	25
<i>TABLE 3 GLOBAL SHIPMENTS OF RAILWAY LOCOMOTIVES AND ROLLING STOCK, 2014 (UNITS)</i>	25
Future Shipments	25
<i>TABLE 4 PROJECTED SHIPMENTS OF RAILWAY LOCOMOTIVES AND ROLLING STOCK, THROUGH 2020 (UNITS)</i>	25
Weight and Materials Requirements	26
<i>TABLE 5 AVERAGE WEIGHT OF RAILWAY LOCOMOTIVES AND ROLLING STOCK, 2011 (TONS PER UNIT)</i>	26
<i>FIGURE 11 TOTAL RAILWAY LOCOMOTIVE AND ROLLING STOCK MATERIAL USAGE, 2014-2020 (MILLION TONS)</i>	27
SHIPS	27
Historical Deliveries	27
<i>FIGURE 12 TRENDS IN WORLD SHIP DELIVERIES, 2006-2014 (MILLION TONS)</i>	27
Future Deliveries	28
<i>TABLE 6 PROJECTED SHIP DELIVERIES, THROUGH 2020 (MILLION TONS)</i>	28
<i>FIGURE 13 PROJECTED SHIP DELIVERIES, 2014-2020 (MILLION TONS)</i>	28
Weight and Materials Use	29
<i>FIGURE 14 STEELWEIGHT OF PROJECTED SHIP DELIVERIES, 2014-2020 (MILLION TONS)</i>	29
AIRCRAFT	30
Historical Aircraft Deliveries	30
<i>FIGURE 15 GLOBAL CIVILIAN AIRCRAFT DELIVERIES, 2014 (% OF TOTAL UNITS DELIVERED)</i>	30
Future Deliveries	31
<i>TABLE 7 PROJECTED GLOBAL DELIVERIES OF CIVILIAN AIRCRAFT, THROUGH 2020 (UNITS)</i>	31
<i>FIGURE 16 TRENDS IN GLOBAL DELIVERIES OF CIVILIAN AIRCRAFT, 2014-2020 (UNITS)</i>	32
Weight and Materials Requirements	32
<i>FIGURE 17 TOTAL CIVILIAN AIRCRAFT MATERIALS USAGE, 2014-2020 (TONS)</i>	32
<i>TABLE 8 CIVILIAN AIRCRAFT AVERAGE UNLOADED WEIGHT BY TYPE OF AIRCRAFT, 2014 (LBS.)</i>	33
CHAPTER 4 LIGHTWEIGHT MATERIALS FOR TRANSPORTATION APPLICATIONS	35
OVERVIEW	35

TOPIC	PAGE NO.
METALS AND ALLOYS	35
High-Strength Steel	35
Description	35
Technologies	36
Carbon-Manganese Steel	36
High-Strength Low-Alloy Steels	36
Advanced High-Strength Steels	36
Dual-Phase Steels	37
Transformation-Induced Plasticity Steels	37
High Hole Expansion Steels	37
Complex Phase Steels	37
Martensitic Steels	38
End Users and Applications	38
<i>TABLE 9 MAJOR END USES AND APPLICATIONS OF HIGH-STRENGTH STEEL</i>	38
Motor Vehicles	38
Body Structures	38
Other Applications	39
Suspensions	39
Light Truck Structures	39
Rail Cars	40
Shipbuilding	40
Prices	40
<i>FIGURE 18 TRENDS IN GLOBAL CARBON STEEL PRICES, 1995-2014 (APRIL 1994 = 100)</i>	40
Manufacturers	41
<i>TABLE 10 MAJOR MANUFACTURERS OF LIGHTWEIGHT STEEL FOR TRANSPORTATION APPLICATIONS</i>	42
Aluminum	42
General Description	42
Types of Aluminum Alloys	42
<i>TABLE 11 ALUMINUM ALLOY DESIGNATIONS</i>	43
End Users and Applications	44
Motor Vehicles	44
<i>TABLE 12 AVERAGE LIGHT VEHICLE ALUMINUM CONTENT BY REGION OF MANUFACTURE, THROUGH 2015 (LBS. PER VEHICLE)</i>	45
<i>FIGURE 19 TRENDS IN AVERAGE LIGHT VEHICLE ALUMINUM CONTENT BY REGION OF MANUFACTURE, 2002-2015 (LBS. PER VEHICLE)</i>	45
<i>FIGURE 20 MAIN ALUMINUM APPLICATIONS IN PASSENGER CARS AND LIGHT TRUCKS, 2012* (LBS. PER VEHICLE)</i>	46
Railway Locomotives and Rolling Stock	47
Shipbuilding	47
Aircraft	48
Light Aircraft	48
Commercial Airliners and Transport Aircraft	48
Helicopters	49
Prices	49
<i>FIGURE 21 ALUMINUM ALLOY PRICE TRENDS, 1995-2014 (\$/SHORT TON)</i>	49
Manufacturers	51

TOPIC	PAGE NO.
<i>TABLE 13 MAJOR MANUFACTURERS OF ALUMINUM FOR TRANSPORTATION APPLICATIONS</i>	51
Titanium	51
Description	51
Material Types	52
<i>TABLE 14 TITANIUM ALLOYS COMMONLY USED IN AEROSPACE APPLICATIONS</i>	53
End Users and Applications	53
Motor Vehicles	53
<i>TABLE 15 TITANIUM APPLICATIONS IN MOTOR VEHICLES</i>	54
Exhausts	54
Springs	54
Engine Valves	54
Shipbuilding	55
Aircraft	55
Prices	56
Manufacturers	56
<i>TABLE 16 MAJOR SUPPLIERS OF TITANIUM AND TITANIUM PRODUCTS FOR TRANSPORTATION APPLICATIONS</i>	56
Magnesium	57
Description	57
Material Types	57
End Users and Applications	57
Motor Vehicles	58
Aircraft	58
Prices	58
<i>FIGURE 22 TRENDS IN AVERAGE MAGNESIUM PRICES, 2014-2020 (\$/TON)</i>	58
Manufacturers	59
<i>TABLE 17 MAJOR SUPPLIERS OF MAGNESIUM AND MAGNESIUM PRODUCTS FOR TRANSPORTATION APPLICATIONS</i>	60
PLASTICS	60
Description	60
Material Types	61
Commonly Used Plastics	61
<i>TABLE 18 COMMONLY USED PLASTICS IN TRANSPORTATION APPLICATIONS</i>	61
Polypropylene	62
Polyvinyl Chloride	62
Thermoplastic Olefins	63
Polycarbonate	63
Polyurethane	63
Polyethylene	63
Nylon	64
Acrylonitrile Butadiene Styrene	64
Polyetheretherketone	64
Polyphenyl Sulfone	65
Polyetherimide	65
End Users and Applications	65
Motor Vehicles	65
<i>TABLE 19 TYPICAL PLASTICS APPLICATIONS IN MOTOR VEHICLES</i>	67

TOPIC	PAGE NO.
Aircraft	67
<i>TABLE 20 TYPICAL PLASTICS APPLICATIONS IN AIRCRAFT</i>	68
Other End Uses and Applications	68
Prices	68
<i>TABLE 21 PRICES OF PLASTICS USED IN TRANSPORTATION APPLICATIONS, 2015 (AVERAGE \$/LB.)</i>	69
Manufacturers	70
<i>TABLE 22 MAJOR MANUFACTURERS OF PLASTICS FOR TRANSPORTATION APPLICATIONS</i>	70
FIBER-REINFORCED POLYMER COMPOSITES	70
Description	70
Material Types	70
Thermoset Composites	71
Resin Systems	71
Polyester	71
<i>TABLE 23 TYPICAL SMC/BMC FORMULATION</i>	71
Epoxies	72
Reinforcements	72
Glass	72
Carbon	73
Thermoplastic Composites	73
Resin Systems	74
Reinforcements	74
Nanocomposites	74
Resin Systems	74
Fillers	74
Montmorillonite	74
Multi-Wall Carbon Nanotubes	75
End Users and Applications	75
Motor Vehicles	75
<i>TABLE 24 TYPICAL COMPOSITE APPLICATIONS IN MOTOR VEHICLES</i>	76
<i>TABLE 25 AUTOMOTIVE APPLICATIONS OF NANOCOMPOSITE MATERIALS</i>	76
Automotive Applications	77
Railway Equipment	78
Shipbuilding	78
Aircraft	79
Prices	80
Manufacturers	80
<i>TABLE 26 MAJOR MANUFACTURERS OF POLYMER COMPOSITES FOR TRANSPORTATION APPLICATIONS</i>	80
METAL MATRIX COMPOSITES	81
Description	81
Types of Materials	82
Aluminum Composites	82
Superalloy Composites	82
Titanium Composites	82
End Users and Applications	83
Motor Vehicles	83

TOPIC	PAGE NO.
<i>TABLE 27 POTENTIAL AUTOMOTIVE APPLICATIONS OF MMCS</i>	83
Railway Equipment	84
Aircraft	84
<i>TABLE 28 POTENTIAL COMMERCIAL/GENERAL AVIATION APPLICATIONS OF MMCS</i>	84
Prices	84
Manufacturers	85
<i>TABLE 29 MAJOR MANUFACTURERS OF METAL MATRIX COMPOSITES FOR TRANSPORTATION APPLICATIONS</i>	85
HYBRID MATERIALS	85
Description	85
Material Types	85
Plastic/Metal Hybrids	86
Fiber-Reinforced Metal Laminates	86
End Users and Applications	87
Motor Vehicles	87
Front Ends	87
Other Components	87
Aircraft	88
Manufacturers	88
<i>TABLE 30 MAJOR MANUFACTURERS OF HYBRID MATERIALS FOR TRANSPORTATION APPLICATIONS</i>	88
CHAPTER 5 PATENT ANALYSIS	90
OVERVIEW	90
PATENTS BY TYPE OF MATERIAL	90
<i>FIGURE 23 U.S. PATENTS ISSUED THROUGH MAY 15, 2015, RELATING TO LIGHTWEIGHT MATERIALS FOR TRANSPORTATION APPLICATIONS, BY TYPE OF MATERIAL (PERCENTAGE OF ALL PATENTS)</i>	90
PATENTS BY TYPE OF TRANSPORT APPLICATION	91
<i>FIGURE 24 U.S. PATENTS ISSUED THROUGH MAY 15, 2015, RELATING TO LIGHTWEIGHT MATERIALS FOR TRANSPORTATION APPLICATIONS, BY TYPE OF APPLICATION (%)</i>	91
CHAPTER 6 PUBLIC POLICY DIMENSIONS OF LIGHTWEIGHT MATERIALS	94
BACKGROUND	94
UNITED STATES	94
FUEL ECONOMY STANDARDS	94
Energy Policy and Conservation Act of 1975	94
National Energy Act of 1978	95
State and Local Legislation	96
SAFETY STANDARDS	96
EUROPEAN UNION	96
FISCAL POLICY	96
Motor Vehicle Fuel Taxes	96
Taxes on Jet Fuel	97
Carbon Charges	97
SAFETY STANDARDS	98
JAPAN	98
FUEL ECONOMY STANDARDS	98

TOPIC	PAGE NO.
FUEL TAXES	99
SAFETY STANDARDS	99
OTHER COUNTRIES	99
CHINA	99
Fuel Economy Standards	99
Vehicle Safety Standards	100
INDIA	100
CHAPTER 7 GLOBAL MARKET FOR LIGHTWEIGHT MATERIALS USED IN TRANSPORTATION EQUIPMENT	102
SUMMARY	102
OVERALL MARKET	102
FIGURE 25 TRENDS IN GLOBAL MARKET FOR LIGHTWEIGHT MATERIALS USED IN TRANSPORTATION EQUIPMENT, 2014 THROUGH 2020 (MILLION TONS/\$ BILLIONS)	102
MARKET BY TYPE OF MATERIAL	102
TABLE 31 GLOBAL MARKET FOR LIGHTWEIGHT MATERIALS USED IN TRANSPORTATION EQUIPMENT, THROUGH 2020 (MILLION TONS/\$ MILLIONS)	103
FIGURE 26 GLOBAL CONSUMPTION MARKET SHARE FOR LIGHTWEIGHT TRANSPORTATION MATERIALS BY TYPE OF MATERIAL, 2014-2020 (%)	103
FIGURE 27 GLOBAL MARKET SHARE FOR LIGHTWEIGHT TRANSPORTATION MATERIALS BY TYPE OF MATERIAL, 2014-2020 (%)	104
MARKET BY END-USER SEGMENT	105
TABLE 32 GLOBAL MARKET FOR LIGHTWEIGHT MATERIALS USED IN TRANSPORTATION EQUIPMENT BY END-USER SEGMENT, THROUGH 2020 (MILLION TONS/\$ MILLIONS)	105
TABLE 33 GLOBAL CONSUMPTION MARKET SHARE OF LIGHTWEIGHT TRANSPORTATION MATERIALS BY END-USER SEGMENT, THROUGH 2020 (%)	106
DETAILED MARKET ESTIMATES AND PROJECTIONS	107
MOTOR VEHICLES	107
Summary	107
TABLE 34 GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN MOTOR VEHICLES, THROUGH 2020 (MILLION TONS/\$ MILLIONS)	107
FIGURE 28 GLOBAL MARKET SHARE OF LIGHTWEIGHT MATERIALS TONNAGE CONSUMPTION USED IN MOTOR VEHICLES, 2014 TO 2020 (%)	108
FIGURE 29 GLOBAL MARKET SHARE IN VALUE OF LIGHTWEIGHT MATERIALS USED IN MOTOR VEHICLE, 2014 TO 2020 (%)	110
Automobiles and Light Trucks	110
Consumption of Lightweight Materials, 2014	110
FIGURE 30 GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN AUTOS AND LIGHT TRUCKS, 2014 (%)	111
FIGURE 31 AUTOMOBILE AND LIGHT TRUCK CONSUMPTION OF LIGHTWEIGHT MATERIALS, BY TONNAGE AND VALUE, 2014 (%)	111
TABLE 35 LIGHTWEIGHT MATERIALS CONSUMED IN PRODUCTION OF PASSENGER CARS AND LIGHT TRUCKS, 2014 (MILLION TONS/\$ MILLIONS)	113
High-Strength Steel	113
Aluminum	113
Titanium	113
Magnesium	114
Plastics	114
Fiber-Reinforced Plastic Composites	114

TOPIC	PAGE NO.
Metal Matrix Composites	114
Hybrid Materials	114
Market Drivers	115
Production of Passenger Cars and Light Trucks	115
<i>TABLE 36 PROJECTED GLOBAL SHIPMENTS OF PASSENGER CARS AND LIGHT TRUCKS, THROUGH 2020 (MILLION UNITS)</i>	115
<i>FIGURE 32 PROJECTED GLOBAL SHIPMENTS OF PASSENGER CARS AND LIGHT TRUCKS, 2014-2020 (MILLION UNITS)</i>	115
Market Penetration	116
<i>FIGURE 33 MARKET PENETRATION RATIOS FOR LIGHTWEIGHT MATERIALS USED IN AUTOS AND LIGHT TRUCKS, 2014-2020 (%)</i>	116
Price Levels	117
<i>FIGURE 34 PRICE TRENDS FOR LIGHTWEIGHT MATERIALS USED IN AUTOS AND LIGHT TRUCKS, 2014-2020 (\$/TON)</i>	117
Market Projections	118
<i>TABLE 37 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN PASSENGER CARS AND LIGHT TRUCKS, THROUGH 2020</i>	119
<i>FIGURE 35 AUTOMOBILE AND LIGHT TRUCK CONSUMPTION OF LIGHTWEIGHT MATERIALS BY TONNAGE AND VALUE, 2020 (%)</i>	120
Heavy Trucks	122
Consumption of Lightweight Materials, 2014	122
<i>FIGURE 36 GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN HEAVY TRUCKS, 2014 (PERCENTAGE OF TOTAL MATERIALS USED)</i>	123
Market Drivers	123
Production of Heavy Trucks	123
<i>TABLE 38 PROJECTED WEIGHT OF LIGHTWEIGHT MATERIAL USED IN HEAVY TRUCKS, 2015-2020 (MILLION TONS)</i>	124
Lightweight Materials Market Penetration	124
Lightweight Materials Price Trends	124
<i>TABLE 39 PROJECTED AVERAGE PRICE OF ALUMINUM ALLOYS USED IN HEAVY TRUCKS, 2014-2020 (\$/TON)</i>	125
Market Projections	125
<i>TABLE 40 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN HEAVY TRUCKS, THROUGH 2020</i>	125
Buses	126
Consumption of Lightweight Materials, 2014	126
<i>FIGURE 37 GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN BUSES, 2014 (PERCENTAGE OF TOTAL MATERIALS USED)</i>	126
<i>FIGURE 38 CONSUMPTION OF LIGHTWEIGHT MATERIALS IN THE FABRICATION OF BUSES, TONS AND VALUE, 2014 (%)</i>	126
<i>TABLE 41 LIGHTWEIGHT MATERIALS USED IN THE FABRICATION OF BUSES, 2014 (TONS/\$ MILLIONS)</i>	128
Market Drivers	128
Bus Shipments	128
<i>FIGURE 39 TRENDS IN WORLDWIDE SHIPMENTS OF BUSES AND RELATED MATERIALS CONSUMPTION, 2014-2020 (UNITS/MILLION TONS)</i>	128
Lightweight Materials Market Penetration	129
<i>TABLE 42 MARKET PENETRATION RATIOS FOR LIGHTWEIGHT MATERIALS USED IN BUSES, 2014-2020 (PERCENTAGE OF TOTAL MATERIALS WEIGHT)</i>	129
Lightweight Materials Price Trends	129

TOPIC	PAGE NO.
<i>TABLE 43 PRICES OF LIGHTWEIGHT MATERIALS USED IN THE FABRICATION OF BUSES (\$/TON)</i>	129
Market Projections	130
<i>TABLE 44 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN BUSES, THROUGH 2020</i>	130
<i>FIGURE 40 PERCENTAGE SHARE OF CONSUMPTION OF LIGHTWEIGHT MATERIALS IN THE FABRICATION OF BUSES, TONNAGE AND VALUE 2020 (%)</i>	131
RAILWAY LOCOMOTIVES AND ROLLING STOCK	132
Consumption of Lightweight Materials, 2014	132
<i>FIGURE 41 GLOBAL PERCENTAGE SHARE OF CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN RAILWAY EQUIPMENT, 2014 (PERCENTAGE OF TOTAL MATERIALS USED)</i>	132
<i>FIGURE 42 CONSUMPTION OF LIGHTWEIGHT MATERIALS IN THE FABRICATION OF RAILWAY EQUIPMENT (TONNAGE AND VALUE), 2014 (%)</i>	133
<i>TABLE 45 LIGHTWEIGHT MATERIALS USED IN FABRICATION OF RAILWAY EQUIPMENT, 2014 (TONS/\$ MILLIONS)</i>	134
High Strength Steel	134
Aluminum Alloy	135
Plastics	135
FRP Composites	135
Metal Matrix Composites	135
Market Drivers	136
Railway Car Shipments	136
<i>FIGURE 43 TRENDS IN GLOBAL SHIPMENTS OF RAILWAY LOCOMOTIVES AND ROLLING STOCK, 2014-2020 (UNITS/TONS)</i>	136
Lightweight Materials Market Penetration	137
<i>TABLE 46 MARKET PENETRATION RATIOS FOR LIGHTWEIGHT MATERIALS USED IN RAILWAY EQUIPMENT, 2014-2020 (%)</i>	137
Lightweight Materials Price Trends	138
<i>TABLE 47 PRICES OF LIGHTWEIGHT MATERIALS USED IN FABRICATING RAILWAY EQUIPMENT, THROUGH 2020 (\$/TON)</i>	138
Market Projections 2014 through 2020	138
<i>TABLE 48 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN RAILWAY LOCOMOTIVES AND CARS, THROUGH 2020</i>	139
<i>FIGURE 44 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN FABRICATING RAILWAY EQUIPMENT (TONNAGE AND VALUE), 2020 (%)</i>	140
SHIPBUILDING	141
Consumption of Lightweight Materials, 2014	141
<i>FIGURE 45 PERCENTAGE SHARE OF GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN COMMERCIAL SHIPBUILDING, 2014 (PERCENTAGE OF TOTAL MATERIALS USED)</i>	141
<i>FIGURE 46 GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS IN COMMERCIAL SHIPBUILDING (TONNAGE AND VALUE), 2014 (%)</i>	142
<i>TABLE 49 LIGHTWEIGHT MATERIALS USED IN FABRICATING COMMERCIAL SHIPS, 2014 (MILLION TONS/\$ MILLIONS)</i>	143
Market Drivers	143
Ship Production	143
<i>TABLE 50 PROJECTED WEIGHT OF MATERIAL USED IN COMMERCIAL SHIPBUILDING, 2014-2020 (MILLION GROSS TONS)</i>	144
Lightweight Materials Market Penetration	144

TOPIC	PAGE NO.
<i>TABLE 51 MARKET PENETRATION RATIOS FOR LIGHTWEIGHT MATERIALS USED IN COMMERCIAL SHIPBUILDING, 2014-2020 (PERCENTAGE OF TOTAL MATERIALS WEIGHT)</i>	144
Lightweight Materials Price Trends	144
<i>TABLE 52 PRICE TRENDS FOR LIGHTWEIGHT MATERIALS USED IN COMMERCIAL SHIPBUILDING, 2014-2020 (\$ PER TON)</i>	145
Market Projections, 2014 Through 2020	145
<i>TABLE 53 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN SHIPBUILDING, THROUGH 2020</i>	145
<i>FIGURE 47 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN COMMERCIAL SHIPBUILDING (TONNAGE AND VALUE), 2017 (%)</i>	147
COMMERCIAL AND CIVILIAN AIRCRAFT	147
Consumption of Lightweight Materials, 2014	148
<i>FIGURE 48 GLOBAL PERCENTAGE SHARE OF CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN COMMERCIAL AND CIVILIAN AIRCRAFT, 2014 (PERCENTAGE OF TOTAL MATERIALS USED)</i>	148
<i>FIGURE 49 CONSUMPTION OF LIGHTWEIGHT MATERIALS IN COMMERCIAL AND CIVILIAN AIRCRAFT (TONNAGE AND VALUE) 2014 (%)</i>	149
<i>TABLE 54 LIGHTWEIGHT MATERIALS USED IN FABRICATING COMMERCIAL AND CIVILIAN AIRCRAFT, 2014 (TONS/\$ MILLIONS)</i>	150
Market Drivers	151
Production of Civilian Aircraft	151
<i>TABLE 55 PROJECTED WEIGHT OF MATERIALS USED IN COMMERCIAL AND CIVILIAN AIRCRAFT, 2014-2020 (TONS)</i>	152
Lightweight Materials Market Penetration	152
<i>TABLE 56 MARKET PENETRATION RATIOS FOR LIGHTWEIGHT MATERIALS USED IN COMMERCIAL AND CIVILIAN AIRCRAFT, 2014-2020 (PERCENTAGE OF TOTAL WEIGHT OF MATERIALS)</i>	152
Lightweight Materials Price Trends	153
<i>TABLE 57 LIGHTWEIGHT MATERIALS USED IN COMMERCIAL AND CIVILIAN AIRCRAFT, 2014-2020 (\$/TONS)</i>	153
Projected Market through 2020	154
<i>TABLE 58 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN COMMERCIAL AND CIVILIAN AIRCRAFT, THROUGH 2020</i>	154
<i>FIGURE 50 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN COMMERCIAL AND CIVILIAN AIRCRAFT (TONNAGE AND VALUE), 2020 (%)</i>	156
CHAPTER 8 COMPANY PROFILES	159
3M CO.	159
ADVANCED MAGNESIUM ALLOYS CORP.	159
AKZO NOBEL NV	159
ALCOA INC.	159
BASF SE	160
BAYER MATERIAL SCIENCE AG	160
CELANESE CORP.	160
CYTEC INDUSTRIES INC.	161
DOW CHEMICAL CO.	161
E.I. DU PONT DE NEMOURS AND CO.	161
DWA ALUMINUM COMPOSITES	162
EXATEC LLC	162

TOPIC	PAGE NO.
FMW COMPOSITE SYSTEMS INC.	162
FREIGHTCAR AMERICA	162
HANWHA AZDEL INC.	163
HEXCEL CORP.	164
HOLLAND CO.	164
LANXESS AG	164
LYONDELLBASELL INDUSTRIES	164
MAGNESIUM ELEKTRON	165
MARTIN MARIETTA MATERIALS	165
MATERION CORP.	166
MERITOR INC.	166
MESSIER-BUGATTI-DOWTY	166
METAL MATRIX CAST COMPOSITES LLC	166
MX COMPOSITES AB	167
POLYONE CORP.	167
RAYMOR INDUSTRIES INC.	167
RENTON COIL SPRING CO.	168
RHODIA SA	168
SABIC INNOVATIVE PLASTICS	168
SIEMENS AG	169
SOLVAY SA	169
TITANIUM METALS CORP.	169
UBE INDUSTRIES LTD.	170
U.S. STEEL CORP.	170
VERKHNAYA SALDA METALLURGICAL PRODUCTION ASSOC.	170
VICTREX PLC	171

LIST OF TABLES

TABLE HEADING	PAGE NO.
SUMMARY TABLE GLOBAL MARKET FOR LIGHTWEIGHT MATERIALS IN TRANSPORTATION, THROUGH 2020	7
TABLE 1 GLOBAL CONSUMPTION FOR TRANSPORTATION EQUIPMENT MATERIALS BY SEGMENT, THROUGH 2020 (MILLION TONS)	19
TABLE 2 PROJECTED MOTOR VEHICLE PRODUCTION BY TYPE, THROUGH 2020 (MILLION UNITS)	23
TABLE 3 GLOBAL SHIPMENTS OF RAILWAY LOCOMOTIVES AND ROLLING STOCK, 2014 (UNITS)	25
TABLE 4 PROJECTED SHIPMENTS OF RAILWAY LOCOMOTIVES AND ROLLING STOCK, THROUGH 2020 (UNITS)	25
TABLE 5 AVERAGE WEIGHT OF RAILWAY LOCOMOTIVES AND ROLLING STOCK, 2011 (TONS PER UNIT)	26
TABLE 6 PROJECTED SHIP DELIVERIES, THROUGH 2020 (MILLION TONS)	28
TABLE 7 PROJECTED GLOBAL DELIVERIES OF CIVILIAN AIRCRAFT, THROUGH 2020 (UNITS)	31
TABLE 8 CIVILIAN AIRCRAFT AVERAGE UNLOADED WEIGHT BY TYPE OF AIRCRAFT, 2014 (LBS.)	33
TABLE 9 MAJOR END USES AND APPLICATIONS OF HIGH-STRENGTH STEEL	38
TABLE 10 MAJOR MANUFACTURERS OF LIGHTWEIGHT STEEL FOR TRANSPORTATION APPLICATIONS	42
TABLE 11 ALUMINUM ALLOY DESIGNATIONS	43
TABLE 12 AVERAGE LIGHT VEHICLE ALUMINUM CONTENT BY REGION OF MANUFACTURE, THROUGH 2015 (LBS. PER VEHICLE)	45
TABLE 13 MAJOR MANUFACTURERS OF ALUMINUM FOR TRANSPORTATION APPLICATIONS	51
TABLE 14 TITANIUM ALLOYS COMMONLY USED IN AEROSPACE APPLICATIONS	53
TABLE 15 TITANIUM APPLICATIONS IN MOTOR VEHICLES	54
TABLE 16 MAJOR SUPPLIERS OF TITANIUM AND TITANIUM PRODUCTS FOR TRANSPORTATION APPLICATIONS	56
TABLE 17 MAJOR SUPPLIERS OF MAGNESIUM AND MAGNESIUM PRODUCTS FOR TRANSPORTATION APPLICATIONS	60
TABLE 18 COMMONLY USED PLASTICS IN TRANSPORTATION APPLICATIONS	61
TABLE 19 TYPICAL PLASTICS APPLICATIONS IN MOTOR VEHICLES	67
TABLE 20 TYPICAL PLASTICS APPLICATIONS IN AIRCRAFT	68
TABLE 21 PRICES OF PLASTICS USED IN TRANSPORTATION APPLICATIONS, 2015 (AVERAGE \$/LB.)	69
TABLE 22 MAJOR MANUFACTURERS OF PLASTICS FOR TRANSPORTATION APPLICATIONS	70
TABLE 23 TYPICAL SMC/BMC FORMULATION	71
TABLE 24 TYPICAL COMPOSITE APPLICATIONS IN MOTOR VEHICLES	76
TABLE 25 AUTOMOTIVE APPLICATIONS OF NANOCOMPOSITE MATERIALS	76
TABLE 26 MAJOR MANUFACTURERS OF POLYMER COMPOSITES FOR TRANSPORTATION APPLICATIONS	80
TABLE 27 POTENTIAL AUTOMOTIVE APPLICATIONS OF MMCS	83
TABLE 28 POTENTIAL COMMERCIAL/GENERAL AVIATION APPLICATIONS OF MMCS	84
TABLE 29 MAJOR MANUFACTURERS OF METAL MATRIX COMPOSITES FOR TRANSPORTATION APPLICATIONS	85
TABLE 30 MAJOR MANUFACTURERS OF HYBRID MATERIALS FOR TRANSPORTATION APPLICATIONS	88

TABLE HEADING	PAGE NO.
TABLE 31 GLOBAL MARKET FOR LIGHTWEIGHT MATERIALS USED IN TRANSPORTATION EQUIPMENT, THROUGH 2020 (MILLION TONS/\$ MILLIONS)	103
TABLE 32 GLOBAL MARKET FOR LIGHTWEIGHT MATERIALS USED IN TRANSPORTATION EQUIPMENT BY END-USER SEGMENT, THROUGH 2020 (MILLION TONS/\$ MILLIONS)	105
TABLE 33 GLOBAL CONSUMPTION MARKET SHARE OF LIGHTWEIGHT TRANSPORTATION MATERIALS BY END-USER SEGMENT, THROUGH 2020 (%)	106
TABLE 34 GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN MOTOR VEHICLES, THROUGH 2020 (MILLION TONS/\$ MILLIONS)	107
TABLE 35 LIGHTWEIGHT MATERIALS CONSUMED IN PRODUCTION OF PASSENGER CARS AND LIGHT TRUCKS, 2014 (MILLION TONS/\$ MILLIONS)	113
TABLE 36 PROJECTED GLOBAL SHIPMENTS OF PASSENGER CARS AND LIGHT TRUCKS, THROUGH 2020 (MILLION UNITS)	115
TABLE 37 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN PASSENGER CARS AND LIGHT TRUCKS, THROUGH 2020	119
TABLE 38 PROJECTED WEIGHT OF LIGHTWEIGHT MATERIAL USED IN HEAVY TRUCKS, 2015-2020 (MILLION TONS)	124
TABLE 39 PROJECTED AVERAGE PRICE OF ALUMINUM ALLOYS USED IN HEAVY TRUCKS, 2014-2020 (\$/TON)	125
TABLE 40 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN HEAVY TRUCKS, THROUGH 2020	125
TABLE 41 LIGHTWEIGHT MATERIALS USED IN THE FABRICATION OF BUSES, 2014 (TONS/\$ MILLIONS)	128
TABLE 42 MARKET PENETRATION RATIOS FOR LIGHTWEIGHT MATERIALS USED IN BUSES, 2014-2020 (PERCENTAGE OF TOTAL MATERIALS WEIGHT)	129
TABLE 43 PRICES OF LIGHTWEIGHT MATERIALS USED IN THE FABRICATION OF BUSES (\$/TON)	129
TABLE 44 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN BUSES, THROUGH 2020	130
TABLE 45 LIGHTWEIGHT MATERIALS USED IN FABRICATION OF RAILWAY EQUIPMENT, 2014 (TONS/\$ MILLIONS)	134
TABLE 46 MARKET PENETRATION RATIOS FOR LIGHTWEIGHT MATERIALS USED IN RAILWAY EQUIPMENT, 2014-2020 (%)	137
TABLE 47 PRICES OF LIGHTWEIGHT MATERIALS USED IN FABRICATING RAILWAY EQUIPMENT, THROUGH 2020 (\$/TON)	138
TABLE 48 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN RAILWAY LOCOMOTIVES AND CARS, THROUGH 2020	139
TABLE 49 LIGHTWEIGHT MATERIALS USED IN FABRICATING COMMERCIAL SHIPS, 2014 (MILLION TONS/\$ MILLIONS)	143
TABLE 50 PROJECTED WEIGHT OF MATERIAL USED IN COMMERCIAL SHIPBUILDING, 2014-2020 (MILLION GROSS TONS)	144
TABLE 51 MARKET PENETRATION RATIOS FOR LIGHTWEIGHT MATERIALS USED IN COMMERCIAL SHIPBUILDING, 2014-2020 (PERCENTAGE OF TOTAL MATERIALS WEIGHT)	144
TABLE 52 PRICE TRENDS FOR LIGHTWEIGHT MATERIALS USED IN COMMERCIAL SHIPBUILDING, 2014-2020 (\$ PER TON)	145
TABLE 53 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN SHIPBUILDING, THROUGH 2020	145
TABLE 54 LIGHTWEIGHT MATERIALS USED IN FABRICATING COMMERCIAL AND CIVILIAN AIRCRAFT, 2014 (TONS/\$ MILLIONS)	150
TABLE 55 PROJECTED WEIGHT OF MATERIALS USED IN COMMERCIAL AND CIVILIAN AIRCRAFT, 2014-2020 (TONS)	152

TABLE HEADING	PAGE NO.
TABLE 56 MARKET PENETRATION RATIOS FOR LIGHTWEIGHT MATERIALS USED IN COMMERCIAL AND CIVILIAN AIRCRAFT, 2014-2020 (PERCENTAGE OF TOTAL WEIGHT OF MATERIALS)	152
TABLE 57 LIGHTWEIGHT MATERIALS USED IN COMMERCIAL AND CIVILIAN AIRCRAFT, 2014-2020 (\$/TONS)	153
TABLE 58 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN COMMERCIAL AND CIVILIAN AIRCRAFT, THROUGH 2020	154

LIST OF FIGURES

FIGURE TITLE	PAGE NO.
SUMMARY FIGURE GLOBAL MARKET FOR LIGHTWEIGHT MATERIALS IN TRANSPORTATION, 2014-2020 (MILLION TONS/\$ MILLIONS)	7
FIGURE 1 TRANSPORTATION SECTOR SHARE OF GLOBAL LIQUID FUELS CONSUMPTION, 2012 AND 2035 (%)	10
FIGURE 2 GLOBAL FUEL CONSUMPTION BY TRANSPORT MODE, 2014 (%)	11
FIGURE 3 GLOBAL TRANSPORT SECTOR CONTRIBUTION TO GREENHOUSE GAS EMISSIONS, 2014 (%)	13
FIGURE 4 COMPARATIVE COST/STRENGTH OF STEEL VERSUS LIGHTWEIGHT MATERIALS FOR VEHICLE PRIMARY STRUCTURES (\$/LB AND GPA)	16
FIGURE 5 GLOBAL CONSUMPTION FOR TRANSPORTATION EQUIPMENT MATERIALS BY SEGMENT, 2014-2020 (MILLION TONS)	20
FIGURE 6 GLOBAL CONSUMPTION SHARE FOR TRANSPORTATION EQUIPMENT MATERIALS BY SEGMENT, 2014 VERSUS 2020 (%)	20
FIGURE 7 GLOBAL PRODUCTION SHARE FOR MOTOR VEHICLES BY TYPE, 2014 (%)	22
FIGURE 8 PROJECTED MOTOR VEHICLE PRODUCTION BY TYPE, 2014-2020 (MILLION UNITS)	23
FIGURE 9 AVERAGE VEHICLE WEIGHTS BY CLASS, 2014 (LBS.)	23
FIGURE 10 TOTAL MOTOR VEHICLE MATERIAL USAGE, 2014-2020 (MILLION TONS)	24
FIGURE 11 TOTAL RAILWAY LOCOMOTIVE AND ROLLING STOCK MATERIAL USAGE, 2014-2020 (MILLION TONS)	27
FIGURE 12 TRENDS IN WORLD SHIP DELIVERIES, 2006-2014 (MILLION TONS)	27
FIGURE 13 PROJECTED SHIP DELIVERIES, 2014-2020 (MILLION TONS)	28
FIGURE 14 STEELWEIGHT OF PROJECTED SHIP DELIVERIES, 2014-2020 (MILLION TONS)	29
FIGURE 15 GLOBAL CIVILIAN AIRCRAFT DELIVERIES, 2014 (% OF TOTAL UNITS DELIVERED)	30
FIGURE 16 TRENDS IN GLOBAL DELIVERIES OF CIVILIAN AIRCRAFT, 2014-2020 (UNITS)	32
FIGURE 17 TOTAL CIVILIAN AIRCRAFT MATERIALS USAGE, 2014-2020 (TONS)	32
FIGURE 18 TRENDS IN GLOBAL CARBON STEEL PRICES, 1995-2014 (APRIL 1994 = 100)	40
FIGURE 19 TRENDS IN AVERAGE LIGHT VEHICLE ALUMINUM CONTENT BY REGION OF MANUFACTURE, 2002-2015 (LBS. PER VEHICLE)	45
FIGURE 20 MAIN ALUMINUM APPLICATIONS IN PASSENGER CARS AND LIGHT TRUCKS, 2012* (LBS. PER VEHICLE)	46
FIGURE 21 ALUMINUM ALLOY PRICE TRENDS, 1995-2014 (\$/SHORT TON)	49
FIGURE 22 TRENDS IN AVERAGE MAGNESIUM PRICES, 2014-2020 (\$/TON)	58
FIGURE 23 U.S. PATENTS ISSUED THROUGH MAY 15, 2015, RELATING TO LIGHTWEIGHT MATERIALS FOR TRANSPORTATION APPLICATIONS, BY TYPE OF MATERIAL (PERCENTAGE OF ALL PATENTS)	90
FIGURE 24 U.S. PATENTS ISSUED THROUGH MAY 15, 2015, RELATING TO LIGHTWEIGHT MATERIALS FOR TRANSPORTATION APPLICATIONS, BY TYPE OF APPLICATION (%)	91
FIGURE 25 TRENDS IN GLOBAL MARKET FOR LIGHTWEIGHT MATERIALS USED IN TRANSPORTATION EQUIPMENT, 2014 THROUGH 2020 (MILLION TONS/\$ BILLIONS)	102
FIGURE 26 GLOBAL CONSUMPTION MARKET SHARE FOR LIGHTWEIGHT TRANSPORTATION MATERIALS BY TYPE OF MATERIAL, 2014-2020 (%)	103
FIGURE 27 GLOBAL MARKET SHARE FOR LIGHTWEIGHT TRANSPORTATION MATERIALS BY TYPE OF MATERIAL, 2014-2020 (%)	104
FIGURE 28 GLOBAL MARKET SHARE OF LIGHTWEIGHT MATERIALS TONNAGE CONSUMPTION USED IN MOTOR VEHICLES, 2014 TO 2020 (%)	108

FIGURE TITLE	PAGE NO.
FIGURE 29 GLOBAL MARKET SHARE IN VALUE OF LIGHTWEIGHT MATERIALS USED IN MOTOR VEHICLE, 2014 TO 2020 (%)	110
FIGURE 30 GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN AUTOS AND LIGHT TRUCKS, 2014 (%)	111
FIGURE 31 AUTOMOBILE AND LIGHT TRUCK CONSUMPTION OF LIGHTWEIGHT MATERIALS, BY TONNAGE AND VALUE, 2014 (%)	111
FIGURE 32 PROJECTED GLOBAL SHIPMENTS OF PASSENGER CARS AND LIGHT TRUCKS, 2014-2020 (MILLION UNITS)	115
FIGURE 33 MARKET PENETRATION RATIOS FOR LIGHTWEIGHT MATERIALS USED IN AUTOS AND LIGHT TRUCKS, 2014-2020 (%)	116
FIGURE 34 PRICE TRENDS FOR LIGHTWEIGHT MATERIALS USED IN AUTOS AND LIGHT TRUCKS, 2014-2020 (\$/TON)	117
FIGURE 35 AUTOMOBILE AND LIGHT TRUCK CONSUMPTION OF LIGHTWEIGHT MATERIALS BY TONNAGE AND VALUE, 2020 (%)	120
FIGURE 36 GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN HEAVY TRUCKS, 2014 (PERCENTAGE OF TOTAL MATERIALS USED)	123
FIGURE 37 GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN BUSES, 2014 (PERCENTAGE OF TOTAL MATERIALS USED)	126
FIGURE 38 CONSUMPTION OF LIGHTWEIGHT MATERIALS IN THE FABRICATION OF BUSES, TONS AND VALUE, 2014 (%)	126
FIGURE 39 TRENDS IN WORLDWIDE SHIPMENTS OF BUSES AND RELATED MATERIALS CONSUMPTION, 2014-2020 (UNITS/MILLION TONS)	128
FIGURE 40 PERCENTAGE SHARE OF CONSUMPTION OF LIGHTWEIGHT MATERIALS IN THE FABRICATION OF BUSES, TONNAGE AND VALUE 2020 (%)	131
FIGURE 41 GLOBAL PERCENTAGE SHARE OF CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN RAILWAY EQUIPMENT, 2014 (PERCENTAGE OF TOTAL MATERIALS USED)	132
FIGURE 42 CONSUMPTION OF LIGHTWEIGHT MATERIALS IN THE FABRICATION OF RAILWAY EQUIPMENT (TONNAGE AND VALUE), 2014 (%)	133
FIGURE 43 TRENDS IN GLOBAL SHIPMENTS OF RAILWAY LOCOMOTIVES AND ROLLING STOCK, 2014-2020 (UNITS/TONS)	136
FIGURE 44 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN FABRICATING RAILWAY EQUIPMENT (TONNAGE AND VALUE), 2020 (%)	140
FIGURE 45 PERCENTAGE SHARE OF GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN COMMERCIAL SHIPBUILDING, 2014 (PERCENTAGE OF TOTAL MATERIALS USED)	141
FIGURE 46 GLOBAL CONSUMPTION OF LIGHTWEIGHT MATERIALS IN COMMERCIAL SHIPBUILDING (TONNAGE AND VALUE), 2014 (%)	142
FIGURE 47 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN COMMERCIAL SHIPBUILDING (TONNAGE AND VALUE), 2017 (%)	147
FIGURE 48 GLOBAL PERCENTAGE SHARE OF CONSUMPTION OF LIGHTWEIGHT MATERIALS USED IN COMMERCIAL AND CIVILIAN AIRCRAFT, 2014 (PERCENTAGE OF TOTAL MATERIALS USED)	148
FIGURE 49 CONSUMPTION OF LIGHTWEIGHT MATERIALS IN COMMERCIAL AND CIVILIAN AIRCRAFT (TONNAGE AND VALUE) 2014 (%)	149
FIGURE 50 PROJECTED CONSUMPTION OF LIGHTWEIGHT MATERIALS IN COMMERCIAL AND CIVILIAN AIRCRAFT (TONNAGE AND VALUE), 2020 (%)	156