

Attn: Greg Walker
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AI and Predictive Maintenance in Intelligent Buildings

CLOSING DATE

April 23, 2021

4:00pm ET

FROM: Harbor Research

Evidence of Knowledge and Experience (12.2, 13.2)

Harbor Research brings to this project substantial industry experience, and a team with relevant expertise in connected product solutions for the Internet of Things, intelligent buildings and artificial intelligence. Beyond Harbor Research's internal knowledge and expertise, we access thought leadership from our wider community of industry experts in intelligent buildings, building security as well as advanced data-intensive, artificial intelligence and predictive maintenance applications. Senior staff will oversee and manage this research effort as well as participate in a focused and applied manner on the scope, design, and execution of this research program.

Glen Allmendinger - President and Founder

Glen is the founder and president of Harbor Research, a strategy consulting firm with offices in Boulder, Colorado and Berlin, Germany. Since the firm's inception in 1983, Allmendinger has worked closely with a broad spectrum of telecommunications, information systems, security, electronics, and automation and equipment manufacturing companies in North America, Europe, and the Far East. These companies range in scope from small, entrepreneurial start-ups to major multi-national corporations. His project direction and consulting has assisted these firms in the development of corporate and business unit strategies, new product, market and service opportunities, and new core capabilities. Glen has consulted to the National Research Council on technology and competitiveness as well as emerging technologies for social wellbeing. He is a member of IEEE, ASME, and ACM and has worked closely with several industry trade associations including CABA. He has worked on DARPA-funded research focused on advanced analytics and sensing systems technology and was a key participant in the planning and development of the National Center for Manufacturing Sciences. Allmendinger received his BA from New York University, and completed graduate studies at MIT's Center for Advanced Media Studies.

Harry Pascarella – Vice President

Harry specializes in Industrial IoT with a focus on manufacturing and natural resources markets. Harry works with clients across a variety of industries to validate and dimension their growth strategies and advise on industry segment and application target selections. Recently, Harry conducted several studies in smart buildings including a deep dive into energy management as well as a market study on the larger market that looked at usage behavior. Harry also worked with the largest LED lighting manufacturer in the United States to develop a business case for connected

lighting platforms. Harry received his bachelor's degree in Economics from the University of Colorado – Boulder.

Ralph Lombreglia – Research Director/Principal Analyst

As the Research Director for Harbor, Ralph brings more than 30 years of experience researching emerging technology trends and distilling them into persuasive and understandable writing. In 2005, along with Glen Allmendinger, Ralph co-authored the article “Four Strategies for the Age of Smart Services”, which introduced the concept of smart systems. Since then, Ralph has continued to explore the evolution of technology and connected devices, publishing articles in publications such as The New Yorker, Esquire, and Paris Review. Ralph holds a master's degree in Creative Writing from the Johns Hopkins University.

Daniel Intolubbe-Chmil – Consultant

As a Consultant, Daniel has led research initiatives shaping critical insight around the evolution of high-performance networks across industrial, commercial and enterprise verticals. Daniel also helps keep a pulse on the market, providing curated content and updates to Harbor's real-time market tracking across all sectors of the economy. Dan has helped lead two previous CABA Council engagements, and has deep expertise across networking technologies within buildings and homes. Prior to Harbor, Daniel has conducted economic research to complete his Honors thesis regarding Education Policy, entailing policy/market research and econometric analysis. He graduated from CU Boulder with a degree in Economics and a minor in Humanities.

Michael Levy – Consultant

Michael is a Consultant at Harbor Research with experience leading research projects for a variety of projects across verticals. In particular, he has led research engagements that focused on real-time networking, data analytics and machine learning solutions, and sustainability. Michael participated heavily in the CABA Smart Home as a Service engagement, where he explored in-depth the evolution of connected home business models, applications, and services. Prior to Harbor, Michael worked for a mid-tier consultancy in Washington D.C. that specializes in privacy and cybersecurity, operating security operations centers (SOC) across the United States. He graduated from Northwestern University with a double-major degree in English Literature and German.

Luke Navilliat – Consultant

Luke is a Consultant at Harbor Research with experience leading research projects for a variety of projects across verticals. In particular, he has led research engagements that focused on control, networking and automation solutions for intelligent building environments. Luke has also written a whitepaper detailing the benefits and value propositions of end-to-end building management platforms for an innovative platform and software company. Prior to Harbor, Luke worked for the City of Boulder's Economics department where he determined incentives and fund allocations for businesses in Boulder. He graduated from CU Boulder with a degree in Quantitative Applied Economics.

Evidence of Previous Experience in AI and Predictive Maintenance for Intelligent Buildings (12.3, 13.2, 13.5)

Founded in 1984, Harbor Research Inc. has more than twenty-five years of experience in providing strategic consulting and research services that enable our clients to understand and capitalize on emergent and disruptive opportunities driven by information and communications technology.

Our firm has been involved in the development of the smart systems and machine-to-machine (M2M) market opportunity since 1998. The firm has established a unique competence in developing business models and strategy for the convergence of pervasive computing, global networking and smart systems. Our extensive involvement in developing this market opportunity, through research and consulting, has allowed the firm to engage with clients in the technology supplier community—both large and emergent players—as well as a diverse spectrum of device OEMs, services providers, and end-customers.

Highlights related to our experience include:

- The first comprehensive research study on the Intelligent device networking and M2M arena in 1999;
- Smart systems and IoT forecast modeling work since 2002;
- October 2005 Harvard Business Review article “Four Strategies For The Age of Smart Services” (we were the firm that “named” the concept of Smart Services);
- Over forty-five white papers to date on various opportunities related to smart devices and services;
- Launch of SmartSphere in 2016, first online platform to map relationships of top companies in the IoT space, analysis of 500 players including many in the smart buildings market and custom news tracking software against Harbor’s taxonomies;
- Work with leading intelligent buildings and smart home constituents and market innovators (Cimetrics / Analytika, Skyfoundry, Eaton Residential Business, Tridium, Optimum Energy, Johnson Controls, Pacific Controls, Jones Lang LaSalle, Samsung, Schneider Electric, Honeywell);
- Work with a broad spectrum of intelligent building network equipment and silicon suppliers (Cisco, Dell, HP, IBM, Samsung, AT&T, Verizon, Intel, Qualcomm, Microsoft, etc.);
- Work with what we believe is the largest community of device manufacturers focused on developing Smart Device and Smart Services solutions;
- Collaborated with CABA in 2017 on identifying key demographics and behaviors of single and multi-tenant constituents.
- Collaboration with CABA in 2018 on identifying monetization strategies for intelligent buildings, and in 2019 on the evolution of Connected Home business models culminating in Smart Home as a Service (SHaaS).
- Collaborated with CABA in 2020 on identifying the opportunities represented by Intelligent Building Energy Management Systems

Harbor Research’s recent relevant experience in the arenas of both artificial intelligence, predictive maintenance and intelligent buildings includes more than twenty-five engagements over the last 4 years, including the following illustrative examples:

• **Assessment of New Data Integration and Analytics Opportunities within the Commercial Buildings / Client: Innovative Software Supplier in the Commercial Buildings Market**

Harbor worked with an innovative software supplier to articulate the opportunity associated with its new and differentiated buildings analytics and energy management platform. We developed a white paper focused on how value is created from machine data, the true value potential of leveraging data created by IoT-enabled buildings, the software tools required to manage and analyze IoT building data and the business models made possible by new software technologies

- **Assessment Uptime Solution Planning and Market Development / Client: Cloud-Based After-Sales Service Software Solution Provider**

Harbor worked with a software supplier of aftermarket solutions for original equipment manufacturers and end customers to optimize equipment and service operations through the use of AI and ML.

- **Predictive Maintenance Software Architecture & Business Model Assessment / Client: Solution Provider for Boilers and Boiler Room Systems**

Harbor worked with a leading commercial and industrial boiler manufacturer to help define the company's business model and technology architecture related to predictive maintenance and related applications of smart systems and IoT

- **Opportunity Assessment & Go-To-Market Development for Control in Intelligent Buildings / Client: Large Industrial Controls Supplier***

Harbor leveraged experience across industry verticals to determine the most attractive near-term and long-term opportunities for the client's current suite of industrial control solutions. Included in the research was an analysis of the intelligent buildings vertical focused specifically on critical systems such as HVAC and energy distribution. Harbor was able to map the intelligent buildings ecosystem and determine selling strategies in order to create granular recommendations on go-to-market channels, profitability, end-customer needs, and partnership considerations.

- **Analysis of IoT Applications for Intelligent Buildings / Client: Large Korean Technology Manufacturer***

We focused on developing a comprehensive forecast model to determine the number of connected devices and potential revenue streams; identifying and profiling key competitors in the marketplace; and developing use cases for attractive applications in the intelligent buildings space. Project findings helped client determine attractive applications to pursue as well as helped identify required capabilities for success.

- **Intelligent Building Energy Management Systems / Client: Continental Automation Buildings Association**

Collaborated with CABA and steering committee members in the 2020 Landmark Research project to assess the opportunity presented by energy management systems. This included an extensive user survey and primary research with Intelligent Buildings market experts and suppliers, and highlighted intelligent building energy management for intelligent buildings.

- **Monetization of Intelligent Buildings / Client: Continental Automation Buildings Association**

Collaborated with CABA and steering committee members in the 2018 Landmark Research project to examine existing and new opportunities for the monetization of intelligent buildings technologies, devices, and systems. This included an extensive user survey and primary research with Intelligent Buildings market experts and suppliers, and highlighted Energy Management.

- **Connected Multi-Dwelling Units and The Internet of Things / Client: Continental Automation Buildings Association**

Worked with CABA and steering committee members to develop an opportunity assessment within Connected MDUs, conducting a survey with 1,500 MDU owners, technology suppliers and service providers in the space, including 60 in-depth interviews to validate research findings. The engagement summarized the top IoT application and use case opportunities among primary buyers of technologies in the space, supported by a 5-year smart systems forecast model.

*Contacts for project references available

Other example clients and engagements our team has worked on include:

- **Honeywell** – Building and Residential Control Components – Security Systems Innovation
- **Eaton Electrical** – Development of Home Automation System and Market Analysis for Residential and Light Commercial Opportunities for Network Services
- **Acuity** – Smart Lighting Systems and Services Market Opportunity Assessment
- **Schneider Electric** – Building Management – Energy Management Opportunities

- **Bosch – Corporate Planning** – Residential and Commercial Security Systems Opportunity Analysis
- **Pacific Controls** – Connected Buildings, OEMs and Mobile Professional Opportunity Analysis
- **Siemens** – Smart Buildings and Facilities Market Forecast, 2016-2022
- **Diversey, ABM** – Platform Aggregation Strategy for Commercial Services in Buildings
- **ARM** – Future Mobile/Consumer Security Requirements Analysis
- **Revolv** – Review of Product Plans for Connected Home Automation Offering
- **Tendril Networks** – Analysis of Energy and Related Services for Home and Consumer Markets
- **Intel** – Connected Home Developer Market Analysis – Analysis of Developer Requirements for Hardware Development Kits
- **Cisco Systems** – Connected Consumer and Connected Real Estate Opportunity Analysis and Technology Roadmap for Security Services for Consumer and Commercial Applications
- **Lightsource Energy** – Residential and Commercial Rooftop Solar Energy and Monitoring Services Analysis
- **Ayla Networks** – Smart Home Whitepaper

For additional examples of previous experience related to intelligent buildings, please see Appendix D of this document.

Summary of Harbor Research Project Approach (12.4, 12.5, 13.1, 13.5)

Proposed Project Methodology

Harbor Research is proposing a collaborative project methodology to conduct a market analysis, survey research and industry expert/thought leader interviews for CABA's Intelligent Buildings Council (IBC), including a methodology and supporting work scope to analyze the trends and forces, customer needs, use case opportunities, risks, and ecosystem formation around artificial intelligence technologies as it relates to the intelligent building industry.

Harbor would leverage heavy involvement from senior staff members including Glen Allmendinger and Harry Pascarella. Harry would assist with both the primary and secondary research efforts from which user behavior and interactions with smart speaker and hub technologies would be surfaced. Glen would oversee the entire project, and provide specific insights on players, business models and other market dynamics by tapping into his IoT and consumer market experience and contact base.

To define and develop business opportunities within predictive maintenance and artificial intelligence technologies as they relate to connected intelligent buildings, Harbor would undertake the following activities:

- Review and analyze existing applicable CABA and non-CABA industry research including past CABA research such as Intelligent Buildings and Covid (2021), Intelligent Building Energy Management Systems (2020), Monetization of Intelligent Buildings (2018), Intelligent Buildings Design Implementation (2018), Intelligent Buildings and the Impact of IoT (2017) and other relevant industry research.
- Review previous Harbor Research analyses of predictive maintenance, artificial intelligence, building controls, evolving power generation and distribution dynamics, BMS and control platforms, and intelligent building best practices, including leveraging all of our work with CABA.
- Conduct interviews with CABA membership thought leaders as well as thought leaders in Harbor Research's community and network.
- Create a foundational framework for understanding the evolution of consumer needs and technology priorities in the realm of artificial intelligence (AI) technologies and predictive maintenance solutions, from which the Steering Committee and Harbor Research can collaborate, including:
 - **Trends and forces** that describe the current status and future state of artificial intelligence (AI) and predictive maintenance applications in intelligent buildings
 - An overview of the **technological advances in predictive maintenance**, including the role played by sensors and sensing technologies, as well as the growing importance of **continuous fault detection**
 - Initial set of **risks/vulnerabilities** (e.g. cybersecurity and privacy), **pain points** (e.g. implementation time), **and barriers to adoption** that arise when considering AI and predictive maintenance solutions in intelligent buildings, all of which can be validated or disproved by survey participants (see below).
 - **Market application map and framework** that portrays the range of predictive maintenance and AI solutions within the intelligent buildings market landscape as well as the corresponding factors such as **business models, partnerships, use cases, value propositions, propensity to pay, solution packaging, and models of pricing and selling**.
 - Portrayals that **address relevant requirements (e.g. data management and analytics)** for predictive maintenance and AI solutions based on **top identified use cases** within the target market, including **reductions in warranty claims** and **reductions in the safety concerns** that result from emergency repairs
 - Ecosystems analysis of existing players (**technology suppliers, OEMs, network providers, software vendors, building developers, facility operators, construction firms**, etc.) and emerging players in the predictive maintenance and AI for intelligent buildings industry to identify roles in the value chain.

- **Market sizing model and forecast** for predictive maintenance and artificial intelligence in the intelligent buildings market from 2020 – 2025, identifying the **most attractive sub-segments and use case opportunities**.
 - **Identification of best practices** for predictive maintenance and AI solution delivery (**partnerships, implementation strategies, etc.**) as well as case studies of dominant and innovative companies within predictive maintenance and AI for intelligent buildings.
 - Identification of **new and emerging revenue streams, service innovations and value-added services (as well as the resulting Rol)** enabled by predictive maintenance and AI technologies today.
 - **A predictive maintenance and AI roadmap** for intelligent building stakeholders, covering all CABA member types, to support solution and ecosystem development
 - Initial set of recommendations for how companies participating in the predictive maintenance and artificial intelligence market including technology suppliers, OEMs, building developers and building operators should **position themselves to take full advantage of the opportunity**; to be validated or disproved by interview and survey participants (see below).
- Design a research process design to validate and analyze the proposed market concepts and hypotheses using surveys and in-depth interviews:

Survey

- Harbor will administer an online survey of market participants along with supplemental conversations, the survey will include **500-600 respondents** divided between the following segments: building tenants and occupants, intelligent building operators, intelligent building owners, and intelligent building developers (additional breakouts of survey respondents among these groups to be determined by Harbor and the CABA Intelligent Buildings Council (IBC) Steering Committee). The survey will be designed in conjunction and cooperation with the CABA Intelligent Buildings Council (IBC) Steering Committee. Harbor will plan to explore the use of a preference-based survey approach to understand respondents' behaviors and preferences in relation to artificial intelligence and predictive maintenance in intelligent buildings including:
 - **Modes of interaction** with AI and predictive intelligence in intelligent buildings
 - Key **value drivers and differentiators** from the different stakeholders' point of view, including customer pain points
 - Customer value or use cases **not yet addressed** by the industry
 - Technical maturity and ability to interact with AI in intelligent buildings
 - **Perceived risks** of AI and predictive maintenance in intelligent buildings
 - Top technology **features and functions** required to leverage data created by intelligent buildings that leverage predictive maintenance and AI
 - Technology **adoption rates and likely future technology roadmaps** for AI and predictive maintenance in intelligent buildings
 - Identification of **buying behaviors, adoption hurdles/timing issues, and willingness to pay** inherent in the purchasing process for AI and predictive maintenance solutions in intelligent buildings
 - Preferred modes of interaction and support between suppliers and adopters within the industry
 - The **effect of COVID-19** effect on the perception and adoption of AI technologies in intelligent buildings
- Harbor will conduct this survey with the support of **a reputable panel or multiple panels** will allow us to quickly and effectively deploy this survey to the target audience.

Interviews

- Harbor will conduct parallel supplemental in-depth interviews (**approximately 15-20**) with marketplace stakeholders, building owners, appliance manufacturers, service providers, software players as well as related specialist providers of artificial intelligence technology and predictive maintenance solutions. Interviews will

comprise of a mix of telephone and video interactions based on a discussion guide designed in cooperation with CABA. These interviews will work to understand how technical requirements and user needs are shifting, along with how these marketplace stakeholders expect customers wish to interact with artificial intelligence applications in intelligent buildings, including differences customer needs and technology and competitive movements.

- Harbor will then employ a “Delphi-like” methodology/approach, based on above survey, to conduct a review of research results with a balanced cross-section of thought leaders and industry specialists/experts (**approximately 5-10 people**) to further validate results and provide a balanced coverage and perspective.

Analysis

- Based on the above research and survey work, Harbor will create a series of strategic alternatives that align stakeholders with opportunities across payments and solution delivery opportunities for emerging and current applications and services. This analysis will include:
 - State and Evolution of the Market: Trends & Forces
 - See **Appendix D: Research Questions** for additional details
 - Customer Needs, Adoption, and Buying Behavior for Artificial Intelligence and Predictive Maintenance in Intelligent Buildings
 - See **Appendix D: Research Questions** for additional details
 - Supplier Dynamics and Best Practices in Artificial Intelligence and Predictive Maintenance for Intelligent Buildings
 - See **Appendix D: Research Questions** for additional details
 - Evolution of the Opportunity: Future Considerations for Stakeholders
 - See **Appendix D: Research Questions** for additional details
- Harbor Research will utilize both industry expert interviews and consumer surveys to examine all major aspects of **Artificial Intelligence and Predictive Maintenance in Intelligent Buildings**. The scope will also include recommendations for implementation and integration, specially covering the implications for predictive maintenance and artificial intelligence applications, as well as strategic alternatives that align stakeholders with opportunities, challenges and key considerations arising from implementing these technologies in intelligent buildings.

Acceptance of Deliverables and Project Timeline (12.6, 13.6)

Harbor Research accepts the terms laid out in the RFP delineating the project deliverables as well as the total elapsed timeline for the study.

This proposal adheres to the following guidelines provided:

- We hereby offer to sell and/or supply to the Continental Automated Buildings Association (CABA), for terms and conditions set out herein, the supplies and/or services listed herein and/or any attached sheets at the price(s) set out therefore.
- We hereby certify that the price quoted is not in excess of the price charged anyone else, including our most favored customer, for like services.

Activity	Anticipated Date
Research set-up and kick-off meeting	Late May 2021
Secondary research	June – August 2021
Primary research	June – August 2021
Analysis and reviews	August – September 2021
Draft report delivery	September 2021
Final report delivery	September 2021
Final Webinar (2 hours). A group webinar for all the funding organizations.	October 2021
Organizational Webinars (1 hour each). One webinar for each organization on the Steering Committee.	November 2021
Think Tank Webinar (1 - 2 hour). A group webinar for all the Steering Committee funders. Occurs after the organizational webinars.	November 2021
Industry Webinar (1 hour). To all CABA contacts to present the high-level executive summary findings only. This occurs after the four (4) month embargo period.	2022
Industry Workshop	2022

CABA Membership Status (12.7)

Harbor Research is a current and active member of CABA.

Harbor Research Profile (13.4)

An internationally recognized research, technology, and business development consulting firm, Harbor Research has predicted, tracked, and driven the development of the Internet of Things since our inception in 1984. While our history is long, our strategy is simple: capture and create value by combining accurate data discovery and analysis with creative systems-thinking. It is this mindset that has given us the privilege of working with some of the greatest companies in the world. Today, we continue to work with C-level executives and top management of some of the world's most consistently successful companies and innovative startups. In the same way that the market has flexed and grown over the years, our services and experience have grown to make us the premier service organization you see today. We work with clients in a variety of ways including consulting, advisory, research and content development, thought leadership and workshop facilitation.

Harbor Research has offices in both Denver, Colorado and Berlin, Germany with ample experienced personnel to complete the scope of this project on time and to the highest standards.

Appendix A: RFP Signature (12.8)

As this project is based on a competitive bidding process, only one (1) contract will be awarded, and it will be offered to the bidder whose proposal is deemed by the Steering Committee, Council Executive Committee and CABA to provide the best value. More than one (1) vendor can be selected if a joint proposal is submitted and selected.

Should the total cost of the selected vendor's proposal exceed the available total project budget, CABA and the Steering Committee may work with the vendor to achieve optimization of project scope, research objectives and methodology in accordance with the available project budget. Once the project is awarded, the vendor and CABA will work together to create an official contract. This contract will be signed by both the vendor and CABA prior to the commencement of the research project.

Important Guide: Given the collaborative nature of the research, participation and funding levels of previous Landmark Research studies have allowed for a total budget of between \$80,000 - \$90,000 USD. This will be the estimated budget for this research project. We encourage prospective bidders to be creative in deriving their scope, objectives and cost of the research to provide maximum value.



Glen Allmendinger
President
Harbor Research, Inc.

Date: 23 April 2021

APPENDIX A: Mandatory Requirements and References

RFP Reference	Requirement (Bidder's proposal should repeat exactly as defined in the RFP)	Reference Page
12.2	Evidence of knowledge and experience of personnel of current theory and practice in the Intelligent Building discipline by providing short relevant biographies of all personnel who it is proposed will participate in the project. The vendor's project leader must have a minimum of 10 years relevant experience.	Pages 1-2
12.3	Evidence of previous experience in the Intelligent Building discipline by providing examples of relevant projects prepared for three (3) separate clients within the preceding 48 months. References may be required from these three (3) clients, only if requested by CABA. References are normally not required.	Pages 3-5
12.4	A summary of how the vendor proposes to perform the project and the relevant experience of the proposed staff.	Pages 6-8
12.5	<u>Identify the sample size of both the interviews and surveys.</u>	Pages 7
12.6	Acceptance of deliverables as identified in the Terms of Reference / Prospectus and proposed schedule.	Page 9
12.7	<u>The vendor must be a member of CABA or agree to become a member of CABA (US\$850)</u> (before the RFP is reviewed).	Page 10
12.8	<u>RFP Signature</u> - Bidders must complete, sign (end of Section 17) and return this RFP form prior to the closing date.	Page 11
12.9	<u>Costs must be in \$USD.</u> A fixed price including a full cost breakdown as per Section 16, "Financial Proposal" must be provided.	Financial Proposal
12.10	The Financial Proposal must be submitted as a separate package (PDF document) to the Technical Proposal (<u>NO FINANCIAL INFORMATION MAY APPEAR IN THE TECHNICAL PROPOSAL.</u>)	Financial Proposal

APPENDIX B: Rated Requirements and References

RFP Reference	Requirement (bidder's proposal should repeat exactly as defined in RFP) Technical Rating	Points		Referenced Section/ Page in Bidder's Proposal
		Max.	Min.	
13.1	<p>The methodology section of the proposal will be an analysis of:</p> <ul style="list-style-type: none"> • How the proposal will achieve the stated objectives • The breadth and depth of the proposed work • Effectiveness of the methodology • The innovativeness of the approach • Ability to reach non-traditional stakeholders • The understanding of the issues pertinent to the project • <u>Include the sample size for both the surveys and in-depth interviews</u> • Include the proposed segmentation of the sample groups (surveys and in-depth interviews) • The ideal project will have a North American focus (both Canada and the United States) <p><i>Optional: Additional related research reports, research subscriptions or other material may be used to strengthen the proposal.</i></p>	40		Pages 6-8
13.2	The relevant knowledge and experience of the vendor's proposed staff in the Intelligent Building field and in performing studies of this nature. The vendor must indicate the proposed involvement of the senior staff assigned to the project.	20		Pages 1-2
13.3	The vendor's previous experience in the Intelligent Building sector and in conducting research projects requiring consultation with a broad cross-section of the industry. Previous research will be reviewed.	20		Pages 3-5
13.4	Corporate profile demonstrating a convincing record of fulfilling contracts on time and on budget, depth of personnel capability and other resources.	10		Page 10
13.5	The vendor's knowledge of the Intelligent Building industry both in North America and worldwide (if applicable).	5		Page 3-5, Appendix F
13.6	Timetable, including interim and final stages.	5		Page 9
	TOTAL TECHNICAL POINTS:	100	70	
13.7	Financial Rating – Total price and detailed cost breakdown.	30		
	TOTAL FINANCIAL POINTS:			

APPENDIX C: Additional Experience in the realm of Artificial Intelligence and Predictive Maintenance in Intelligent Buildings

The above requested list of three projects is not a complete list of relevant assessments the firm has completed. Other relevant work includes:

- For the largest social media and networking company in the US, we conducted a demographic research study on a consumer-device prototype to understand the use cases, applications and target constituents in support of a Market Requirements Document.
- For the largest manufacturer of electrical products in North America, we conducted user survey research as well as competitor, peer and alliance candidate direct interviews to uncover unmet customer and user needs for new and evolving “connected” energy management and services opportunities.
- For the global leader in network infrastructure equipment, Harbor conducted an analysis of managed services opportunities in connected residential multi-dwelling and commercial properties, including market sizing, competitor analysis, alliance development analysis and go-to-market design.
- For the world’s largest semiconductor and processor manufacturer, Harbor conducted an analysis of IoT opportunities within the residential sector. Primary emphasis was placed on opportunities where media and content were dominant values to determine core computing and network bandwidth requirements.
- For a venture-backed startup, conducted an analysis of consumer energy services offerings to help target candidate developer alliances as well as partnership opportunities with utilities and related services providers.
- Worked with CABA to develop an opportunity assessment within Connected MDUs, conducting a survey of 1,500 MDU owners, technology suppliers and service providers in the space, including 60 in-depth interviews to validate research findings. The engagement summarized the top IoT application and use case opportunities among primary buyers of technologies in the space, supported by a 5-year smart systems forecast model.
- For a large silicon player, Harbor defined and developed a software architecture for competitive analysis of IoT platforms. This research examined twenty-five supplier and OEM platform providers in the IT, Telco and OEM markets to validate and segment monetization and pricing models.
- For a leading connected lighting solution provider, Harbor defined new and expanded smart services and IoT solutions as well as building the business case required to support this critical growth initiative. Harbor clearly articulated alternative strategies and solutions available to the company and defined clear steps and a program of actions to fully prosecute the market opportunity.
- For the software branch of a leading industrial and energy OEM, Harbor analyzed of the costs and economics of asset performance management in support of asset health, productivity, optimization, and compliance and integrity. Harbor developed a market model that broke down the costs of data management and analytics tools, and located gaps the company’s software may not address currently and can be added to the product roadmap.
- For the largest manufacturer of electrical products in North America, Harbor conducted user survey research as well as competitor, peer and alliance candidate direct interviews to uncover unmet customer and user needs for new and evolving “connected” energy management and services opportunities.
- For the global leader in network infrastructure equipment, Harbor conducted an analysis of managed services opportunities in connected residential multi-dwelling and commercial properties, including market sizing, competitor analysis, alliance development analysis and go-to-market design.
- For a venture-backed startup, conducted an analysis of consumer energy services offerings to help target candidate developer alliances as well as partnership opportunities with utilities and related services providers

APPENDIX D: Research Questions to Be Answered

State and Evolution of the Market: Trends & Forces

- What artificial intelligence and/or predictive maintenance applications are currently being introduced and adopted in intelligent buildings and why? What are the **major barriers to full scale adoption** of new artificial intelligence (“AI”) and predictive maintenance solutions in intelligent buildings?
- How will technologies such as **predictive analytics and maintenance** reduce costs, as well as reduce risks and human interaction, and therefore by implication, also affect the adoption of artificial intelligence in intelligent buildings? And how are these same technologies **enabling new applications and business opportunities** in intelligent buildings?
- What is the **role of network providers** in the evolving use of **artificial intelligence in intelligent buildings** and how will this change with the **private 5G and LTE networks**?
- How does the **intelligent building ecosystem** look as a whole from installation to operation to updates and ownership?
- How will the market **evolve in the near-term and the long-term**? What implications does this have for key stakeholders?
- What is the device and/or market size and forecasted integration, hardware and software revenue **for AI and predictive maintenance in intelligent buildings** from 2020 – 2025? How does this revenue opportunity differ by market segment and application?
- What key regulatory and socioeconomic forces are driving or slowing the adoption of **artificial intelligence and predictive maintenance in intelligent buildings**?
- What are the implications of wider adoption of artificial intelligence for **data ownership, cybersecurity, and data privacy**?
- What are the **ethical and legal implications** as well as potential for greater **government intervention** of wider adoption of artificial intelligence in intelligent buildings?

Customer Needs, Adoption, and Buying Behavior for AI and Predictive Maintenance in Intelligent Buildings

- What **artificial intelligence and/or predictive maintenance applications and use cases** are driving the largest business opportunities in which market sub-segments today?
- What are the **top pain points** customers face when introducing new technology in intelligent buildings? How do top applications and use cases address key customer needs and pain points? How do intelligent building constituents determine **cost-benefit metrics of artificial intelligence** technologies?
- What are the **disconnect between customers and suppliers** when either integrating existing solutions or adopting new artificial intelligence and predictive maintenance solutions?
- What **value propositions and KPIs** do buyers consider most when adopting artificial intelligence and predictive maintenance solutions in intelligent buildings? Are these customers well informed of the **value provided by artificial intelligence and predictive maintenance** solutions in intelligent buildings? How will this evolve in the future?
- How (**pricing models**) and what (**willingness to pay**) are customers willing to pay for artificial intelligence and predictive maintenance solutions in intelligent buildings?
- What are the key differences in customer types? How should positioning, channel and sales tactics differ by customer personas?

- How do customers most often interact with suppliers? What **client budgeting, investment and solution packaging and delivery considerations** do suppliers need to take into account when selling solutions?

Artificial Intelligence and Predictive Maintenance for Intelligent Buildings: Supplier Dynamics and Best Practices

- Who are the **key established players** across each of the following identified segments: hardware and software technology manufacturers and suppliers, OEMs, integrators and installers, service providers?
- Who are the key hardware and **software innovators creating disruption** within the realm of artificial intelligence and predictive maintenance for intelligent buildings? How are they differentiating themselves?
- What **new acquisitions, investments, partnerships and ecosystems** are developing in the market for artificial intelligence and predictive maintenance in intelligent buildings?
- What are **the strengths and weaknesses of the identified players** in the market today? Which business and solution delivery models are the most successful today, and how will this change in the future?
- How does **channel to market** and best practices differ across player type, solution, industry sub-segment, etc.?

Evolution of the Opportunity: Future Considerations for Stakeholders

- **What segments, technologies and software** are being adopted for artificial intelligence and predictive maintenance in intelligent buildings both today and in the future?
- What are the **key socioeconomic and regulatory barriers and opportunities** in the market? How can stakeholders capitalize on these opportunities?
- What are the **best practices for mitigating customer concerns**, communicating value propositions and delivering or integrating artificial intelligence and predictive maintenance solutions for intelligent buildings?
- What major **barriers and difficulties** do suppliers have when delivering artificial intelligence and predictive maintenance solutions for intelligent buildings? How can stakeholders effectively **prepare to address** problems such as proprietary platform software solutions and differences in AI hardware platforms?
- What are the **best practices for pricing and monetizing** artificial intelligence and predictive maintenance solutions in intelligent buildings? What ecosystem participants will stakeholders need to engage to have an effective market channel? What customer behaviors and solution delivery considerations should they be taking into account when determining how best to structure their pricing and revenue models?
- What **Post-Covid opportunities** are presenting themselves as viable business opportunities within the realm of AI and predictive maintenance in intelligent buildings?

APPENDIX E: Current State of Intelligent Buildings

Current State of Intelligent Buildings

The intelligent building systems market is poised to enter a new period of transformation based on the availability of low-cost, wireless IoT technologies and new services offered through innovative business models. This market is experiencing a confluence of IoT data platforms, and a range of market players are trying to determine how to capture these emerging revenue streams from new services and solutions. The combination of available technology with business architectures designed to support these new offerings has the potential to unleash a significant wave of disruption and new value in this evolving arena. Despite this promise, only companies that know how to properly address customer needs and monetize the data produced by IoT-enabled buildings will emerge as winners.

Emerging intelligent building systems provide a distributed control and information system that enables networks of intelligent devices to monitor and control the mechanical systems in a building and integrate data from existing BMS systems. These solutions are enabled by a new class of software tools and data frameworks that allow data to be aggregated from across the fractured vendor ecosystem. **Advanced data management, analytics, AI and machine learning algorithms applied to integrated datasets are identifying and capturing new efficiency gains from building systems.** These new technologies and use cases are not only changing the way that buildings stakeholders operate, but also how they co-operate.

This evolution has fundamentally changed how intelligent buildings solution providers must address the market. Despite all the excitement and hype created around IoT and intelligent buildings, service providers have to overcome a range challenges to realize the full potential of IoT. Some of the major challenges include realizing new growth opportunities that leverage data from IoT-enabled buildings, interoperability, cybersecurity, data ownership, enterprise privacy, customer needs, building a portfolio of IoT products and services for vertical markets, and monetization models for these products and services. Particularly difficult for suppliers is the ability to meet the needs of the range of constituents and stakeholders they serve.

Today's building managers, operators and owners are seeking cost-effective and easy-to-use tools that coordinate the operation of traditional building systems with newly connected IoT systems. As these end-customers mature, they are increasingly asking what value-added services they can enable with their IoT data. Gathering data and storing it in the cloud is not enough; new use cases such as predictive maintenance and operations visibility require tightly integrated systems that look nothing like disparate building spaces they manage and occupy today.

Innovative technologies in intelligent buildings reduce operating and maintenance costs thanks to their ability to collect and analyze data. Sensors placed on equipment can automatically program maintenance activities, which are therefore based on use rather than pre-scheduled intervals. **Predictive maintenance is 3 to 9 times cheaper than a reactive approach**, traditionally achieved when the damage has already occurred. Moreover, with intelligent building management technologies, owners are informed of potential problems before the equipment actually fails. Predictive maintenance can be useful for any building, in any industry. In our experience, much of the activity around predictive maintenance currently is around mechanical equipment, everything from small actuators on a manufacturing line to HVAC blower motors. Interestingly, the **significance of a well-functioning HVAC system has increased** recently due to COVID-19 concerns.

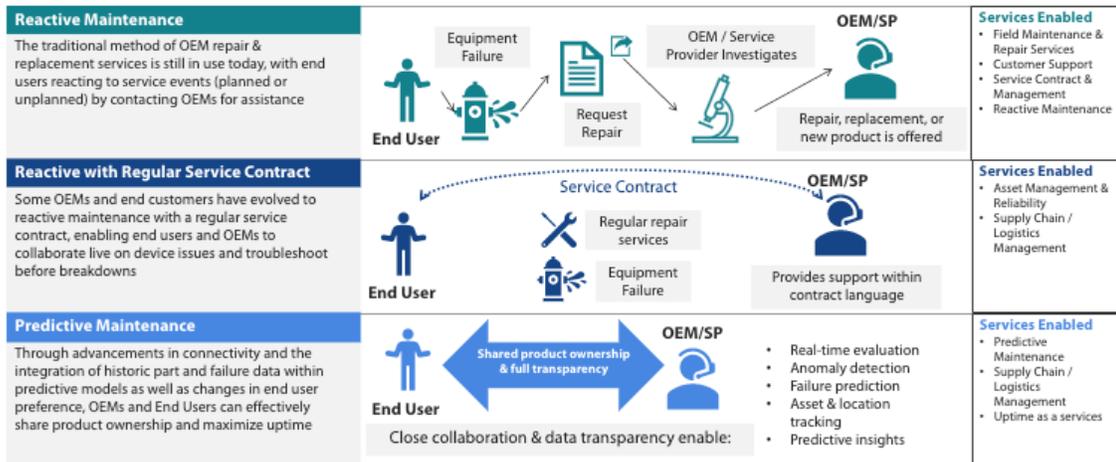
While customers are not ignorant to their benefits, deploying and integrating new maintenance solutions is often a difficult prospect confounded by siloed solutions, customer building improvement budgets and disparate adoption. This has resulted in market confusion; end-customers do not know what they are getting for their money, solution providers do not know what end-customers are willing to pay for, or how offerings should be priced, packaged and deployed. As customers weigh the risks and rewards of predictive maintenance, and other artificial intelligence solutions for buildings, suppliers will need to adopt creative business models and go-to-market strategies in order to effectively demonstrate a healthy Return on Investment.

APPENDIX F: Sample Research

F1. Recent Study "Assessment of Uptime and Predictive Maintenance" in February 2021

The Evolution of Maintenance Solutions Towards Predictive

The adoption of new monitoring, data management, and analytics technologies is enabling predictive maintenance strategies that coordinate OEMs, Service Providers, and end customer personnel in increasing asset uptime



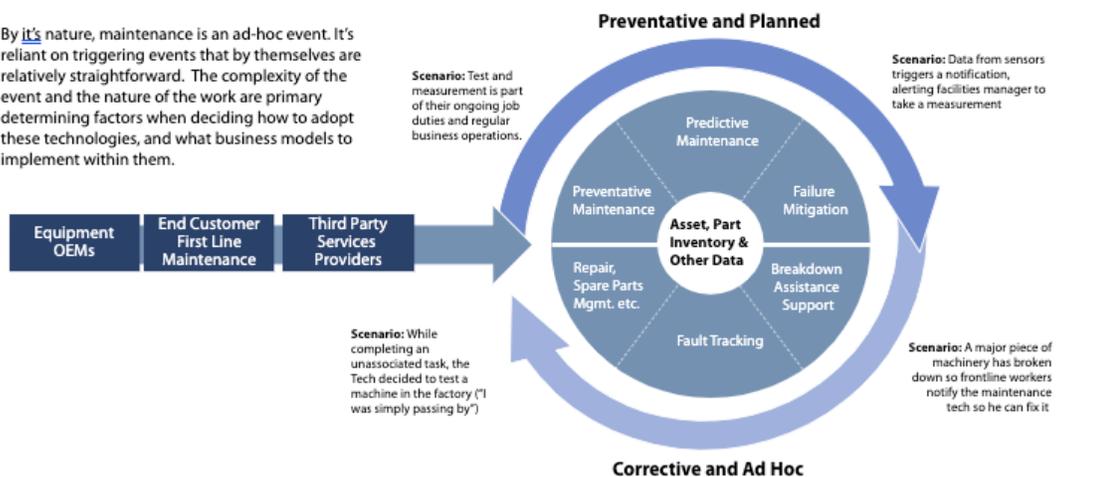
12

Uptime Strategy February 2021 | Harbor Research

Customers Need Better & More Integrated Aftermarket Solutions

The value of digital transformation is gaining traction among end customers, but the complexity of this strategy is causing challenges across all industries.

By its nature, maintenance is an ad-hoc event. It's reliant on triggering events that by themselves are relatively straightforward. The complexity of the event and the nature of the work are primary determining factors when deciding how to adopt these technologies, and what business models to implement within them.

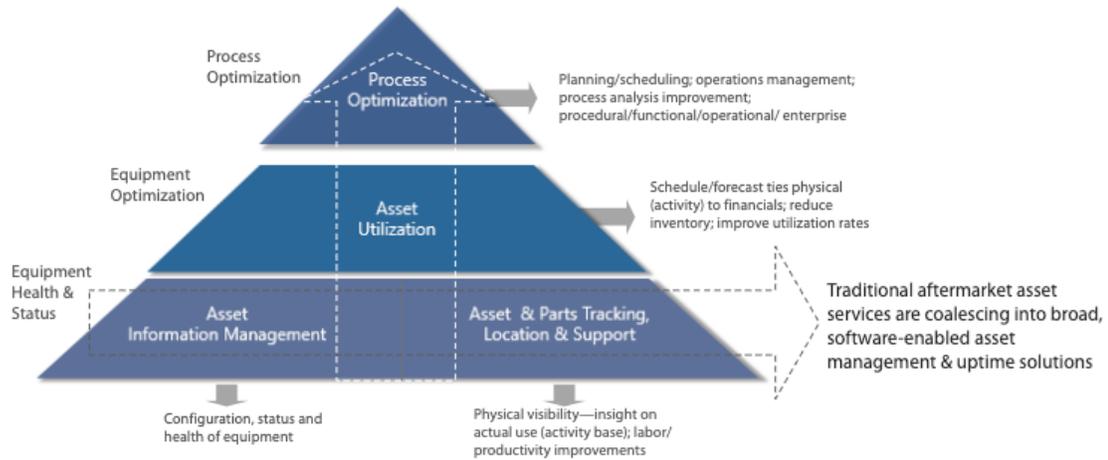


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Uptime Strategy February 2021 | Harbor Research

Aftermarket Asset Management Is A Big Growth Opportunity

Leveraging the value of asset health and systems knowledge is the next big step for mission critical equipment providers and their sub-system and component providers



Overview of Competitor Capabilities & Solution Delivery

Competitor capabilities and delivery differ based on legacy business model but are converging to asset management

Company	Asset Mgmt. & Uptime										Commercialization/GTM			Comments
	Edge Connectivity & Data Ingest	Data Management & Integration	Asset Monitoring & Alerts	Diagnostics & Prognostics	Analytics & Visualizations	Packaged Asset Mgmt. Apps	Field Service Management	Pricing Management	Inventory Management	Supply Chain Management	Enterprise App Integration	Customer Targeting	Solution Delivery	
synchron	Some	Strong	Strong	Strong	Some	Little	Strong	Strong	Some	Some	OEM/3P	Config.	Platform/App	Roadmap focuses on analytics + apps
relayr.	Some	Strong	Strong	Strong	Strong	Some	Some	Little	Little	Little	OEM/3P/EC	Config.	Platform	Offers equipment financing and insurance
UPTAKE	Some	Strong	Strong	Strong	Strong	Some	Some	Little	Little	Little	OEM/3P/EC	Config.	Platform	Targets fleets and dealers specifically
thingworx	Strong	Strong	Strong	Strong	Strong	Some	Little	Little	Little	Little	OEM/3P/EC	Config.	Platform	Significant connectivity expertise; market leader
IBM	Some	Strong	Strong	Strong	Strong	Some	Little	Little	Strong	Some	EC	Config.	Platform/App	End customer focus, but pursuing OEM/3P partners
machinemetrics	Strong	Strong	Strong	Strong	Some	Strong	Some	Little	Little	Little	OEM/3P/EC	Config.	Platform/App	Packaging asset mgmt. apps; has edge device
UpKeep	Some	Strong	Strong	Strong	Some	Some	Little	Strong	Little	Little	OEM/3P/EC	Mixed	App	CMMS-type system with focus on mobile apps
AVEVA	Strong	Strong	Strong	Strong	Some	Some	Little	Little	Little	Strong	EC	Mixed	Platform/App	Offering new subscription model for software
SIEMENS	Strong	Strong	Strong	Strong	Some	Some	Little	Little	Little	Strong	EC	Config.	Platform/App	App marketplace largely fills gaps in captive features
BlueYonder	Little	Strong	Some	Little	Some	Little	Little	Strong	Strong	Strong	EC	Config.	Platform/App	SCM native extending into equipment data & analytics
aws	Strong	Strong	Strong	Some	Some	Little	Little	Little	Little	Strong	OEM/3P/EC	Mixed	Platform/App	Cloud leader extending into equipment monitoring

Methodology: Determining Pain Points, Buyers & Behaviors

The identification of personas and their buying behaviors is based on locating the employee roles involved in pursuing Predictive Maintenance strategies, their pain points, and the common incentives around each OEM's initiative.

1. What are your top pain points related to your equipment & aftermarket solutions?



In general, the pain points do not vary by equipment type or vertical, but it was essential to understand how these pain points may affect each asset and its vertical differently.

2. Who are the buyers & what is the software buying process? What do buyers care about?



Locating the buyers is important to understanding the key personas that need to be interviewed about predictive maintenance initiatives. These are the employees who are most likely to lead a digital strategy, the buying process, integration of the platform, and justification of ROI from the solutions.

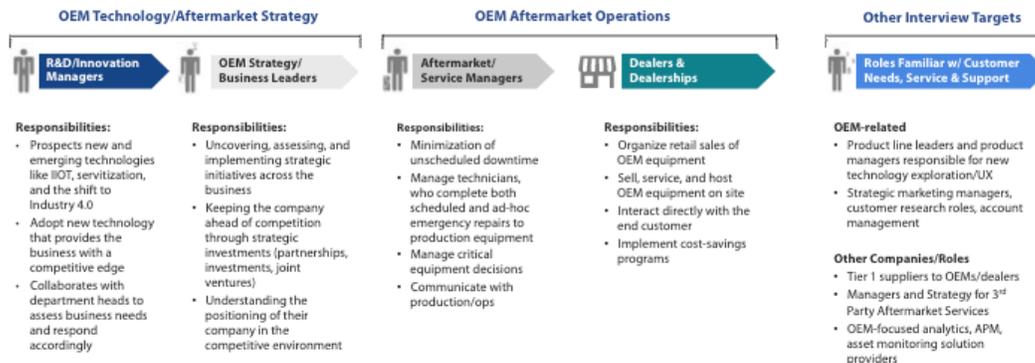
3. What are your investment plans and requirements & who would you buy from?



Once we understand who the buyers are, we can then better target them and understand what their investment requirements are (cost-savings, revenue generation, breakeven timeline, etc.) as well as who the player would buy from (partner, investment, etc.) to inform strategy recommendations

Interview Targets: Uptime Opportunity Validation

Asset management solution decision-making varies across range of personas, but the key roles will be directly involved in the assessment, integration, and daily supply or use of these solutions, as well as related customer needs.



Asset Performance Management TAM to Reach \$500B by 2026

TAM is the estimate of potential spend by all end customers, OEMs and third parties for APM capabilities or substitute software and services.



	2020	2021	2022	2023	2024	2025	2026	CAGR
Resources & Construction	\$9,019	\$10,742	\$12,812	\$15,292	\$18,462	\$22,304	\$26,974	20%
Energy & Utility	\$22,824	\$27,184	\$32,308	\$38,316	\$45,794	\$54,600	\$64,980	19%
Transportation	\$13,138	\$15,388	\$18,018	\$21,015	\$24,704	\$28,924	\$33,721	17%
Industrial	\$62,420	\$78,308	\$97,863	\$121,772	\$151,839	\$188,244	\$232,011	24%
Industrial, Commercial & Institutional Buildings	\$63,879	\$73,391	\$84,594	\$97,737	\$113,073	\$130,835	\$151,344	15%
Total	\$171,279	\$205,012	\$245,596	\$294,133	\$353,871	\$424,908	\$509,029	20%

TAM Scope

OEM Equipment Segments: Tier 1, Tier 2 and Tier 3 OEM Equipment Segments

Revenue Categories:

- a. **Value Added Applications:** Asset Performance Management, Supply Chain & Logistics, Customer Support
- b. **Data & System Applications:** Diagnostics/Prognostics, Automation & Analytics, Location & Tracking, Monitoring & State, Equipment Information, Device management & Connectivity

- F2. CABA 2020 Landmark Research on Intelligent Building Energy Management Systems (CABA members have access to report online)
- F3. CABA 2018 Landmark Research on Connected Home Roadmap (CABA members have access to report online)
- F4. CABA 2016 Landmark Research on MDUs (CABA members have access to report online)

F5. CABA “Smart Home as a Service” Landmark Research 2020

The Evolution to SHaaS

Trends & Forces Driving SHaaS Forward

Consumer privacy concerns force companies like Apple and Google to focus on protecting consumer data in order to gain consumer trust and differentiate their offerings from competitors

Security and energy management players are expanding their reach into home automation and smart home hub providers

Innovative startups like Nest and Ring are penetrating the Smart Home market, forcing large players to devote billions of dollar in acquisitions to maintain their market stranglehold

Younger generations are driving the adoption of smart products and services supported by a greater awareness of technological capabilities

The **prevalence of smartphones and wearables** as core organizing technologies for consumers is driving demand for functionality around the major mobile platforms

Installation of smart home technologies will be a key pain point and differentiator for consumers that demand simple installation and automated integration

Artificial Intelligence (AI) and associated technologies such as machine learning (ML) and natural language processing (NLP) enable more varied and streamlined device interactions

Advances in home networks, such as WiFi and Zigbee, allow devices to have increased range, bandwidth, and latency for more powerful applications like video streaming

Open source platforms and low-code tools like IFTTT allow non technically-savvy users the ability to control devices

Governments are focusing on **consumer security and privacy regulations** that limit the ability of suppliers to collect and share consumer data

Workforce automation tools like Slack and Zoom are blurring the line between the home and the office by allowing for remote work

Aging population becomes a considerable contribution to the demand for medical monitoring and entertainment

Smart Home Services: Consumer Demand Variance

Consumer Types	Preferred Smart Home Services (% "Very Interested" In Subscribing)		
	42%	39%	36%
	45%	44%	42%
	38%	36%	35%
	48%	44%	44%
	27%	26%	23%
	37%	34%	32%

All Survey Respondents' Interest in Smart Home Services

Age Ranges	Income Ranges	SHaaS Services
18-34	\$50k-\$100k	Maintenance-as-a-Service
35-54	\$100k+	Sustainability-as-a-Service
55+		Energy-as-a-Service
		Comfort-as-a-Service
		Security-as-a-Service



(We are currently between stages 1 and 2)

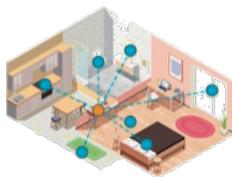
Stage 1: Smart Devices for Home Applications

Few, but rapidly increasing Smart devices operate independently in the Smart Home



Stage 2: Lots of Smart Devices are Controlled by Hub (Alexa)

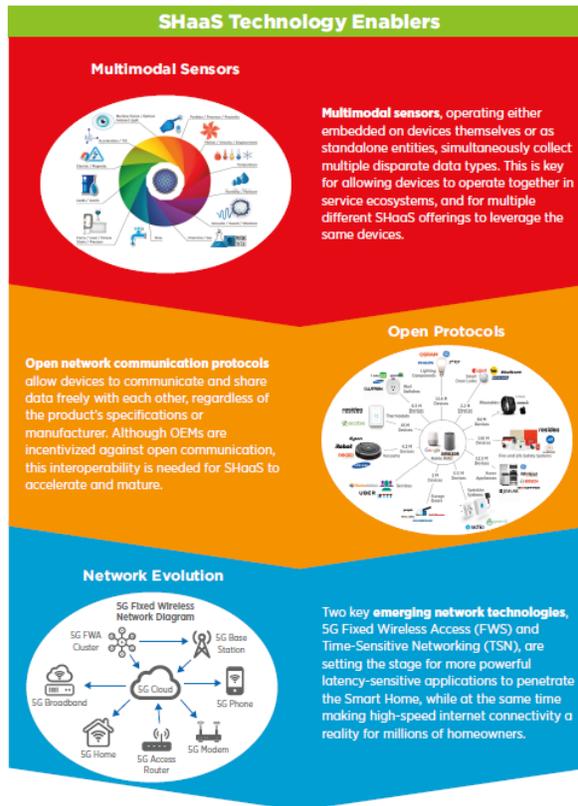
As more and more connected devices infiltrate the Smart Home, users will rely on hubs like Alexa to control them all



● Connected Device

● "Hub" (e.g. Alexa)

☁ Cloud Storage / Processing



Smart Home as a Service (SHaaS)

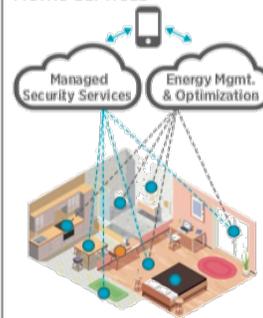
Stage 3: Smart Home Services Provided by Groups of Devices

In SHaaS, managed services such as physical home security are provided through collecting data from many interoperable devices—e.g. audio sensors, doorbell, footfall tracking

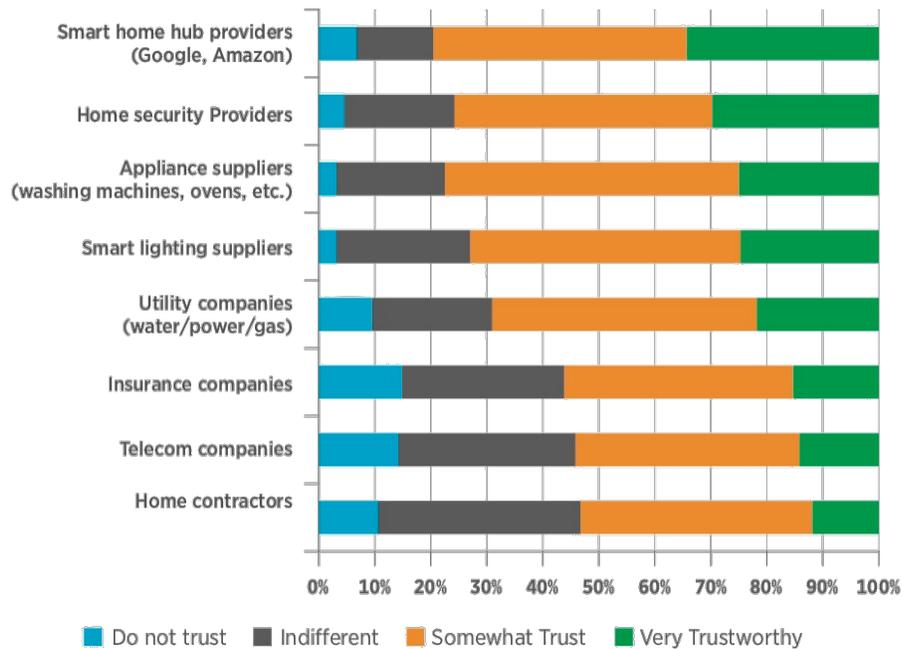


Stage 4: Smart Home Services Managed by Central UI

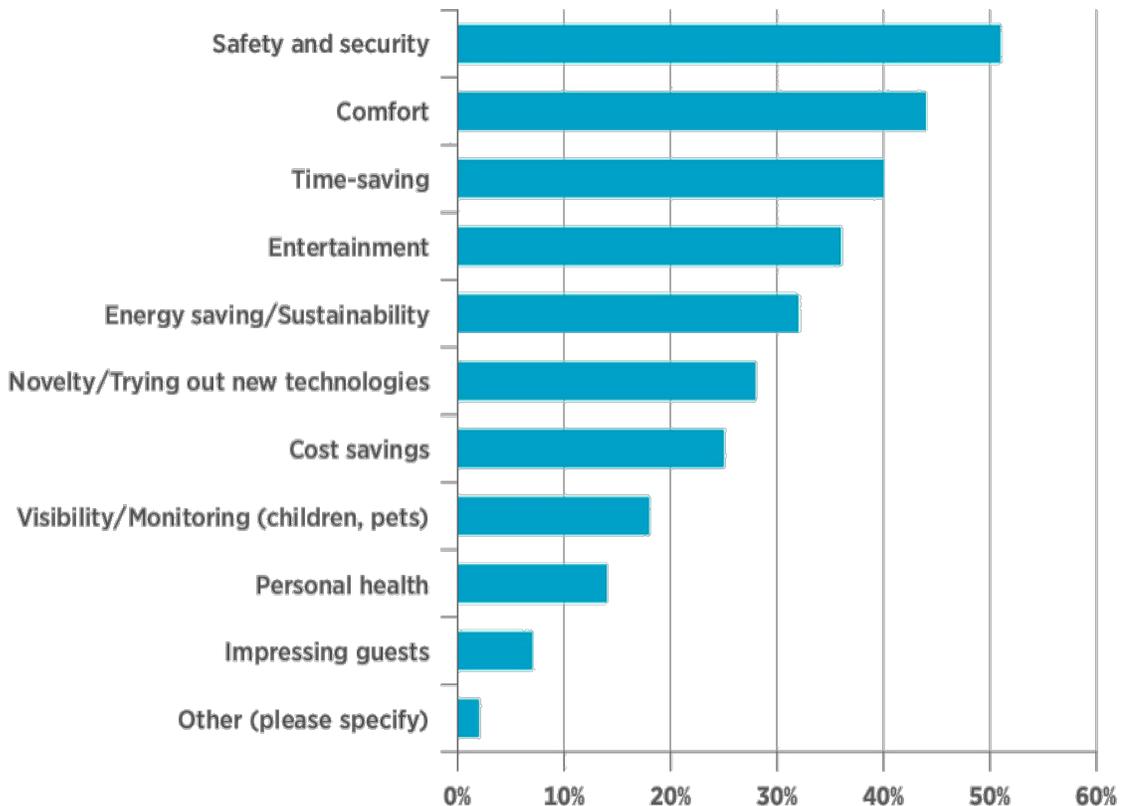
Eventually, SHaaS will create the need for a central, master UI (such as a Smart Phone mobile app) that allows users to monitor, control, and manage all of their Smart Home services



Survey Question: Which of the following home suppliers do you trust most?



Survey Question: What were the primary motivations for adopting the Smart Home technology (security, comfort, etc.)?

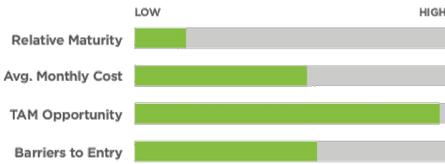


Health & Wellness-as-a-Service

Key Players

American Well®  AWAIR®  Lenovo

Key Attributes

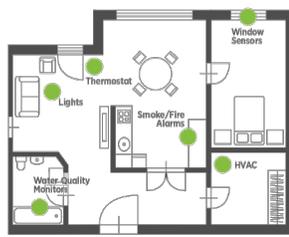


Background and Description

Current Outlook
Health and wellness applications in the Smart Home today are separate and disparate, relying on independent devices such as air quality monitors/sensors or telehealth and medicine wearables.

Future Outlook
Depending on each homeowner's unique health conditions (gleaned from EHRs), devices, sensors, and monitors will work in concert to monitor air, biophilia, and chemical quality to best serve each consumer.

Ecosystem and Device Overview

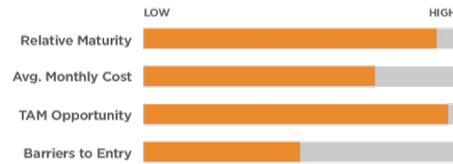


Security-as-a-Service

Key Players

 ADT  ALARM.COM™  resideo  SimpliSafe®

Key Attributes

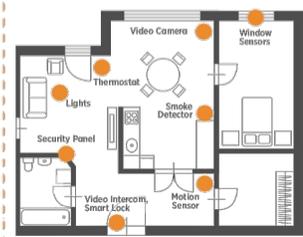


Background and Description

Current Outlook
Currently, home security is sold to consumers as either an independent DIY package of security devices like Smart Locks and cameras, which rely on the user for monitoring and threat detection.

Future Outlook
Innovators like SimpliSafe and Alarm.com are pioneering Home Security-as-a-Service, which over time will incorporate AI and scene intelligence for automated threat detection and deterrence.

Ecosystem and Device Overview



Energy Management-as-a-Service

Key Players

 ENERGY STAR  BOSCH  Hydro Québec

Key Attributes

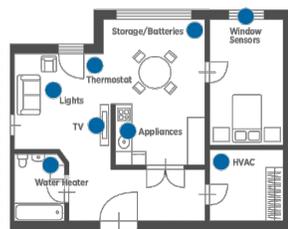


Background and Description

Current Outlook
Currently, state-owned utilities providers offer users little visibility or control into how their home consumes energy. The rise of Smart Meters is beginning to make consumption data widely available.

Future Outlook
In SHaaS, energy management and optimization will enable users to control and adjust energy consumption settings in accordance with their preferences.

Ecosystem and Device Overview

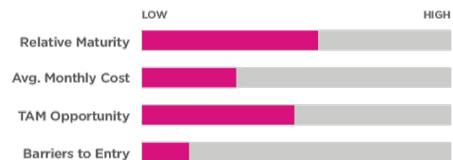


Comfort & Convenience-as-a-Service

Key Players

 Control4  amazon alexa  PHILIPS hue personal wireless lighting

Key Attributes

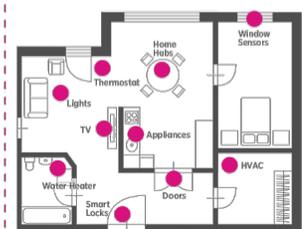


Background and Description

Current Outlook
Currently, some platforms and services exist to allow consumers to automate functions to add convenience to their lives with either voice-activated or fully-automated lights, televisions, and doors.

Future Outlook
In SHaaS, users will pay a monthly subscription for the ability to configure and control comfort "profiles", that control temperature and brightness settings in the home, automatically adjusting throughout the day.

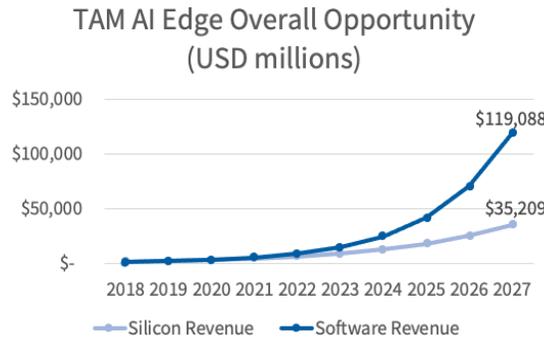
Ecosystem and Device Overview



F6. Recent Study "Artificial Intelligence at the Edge" in August 2018

The market for AI at the edge is large and growing

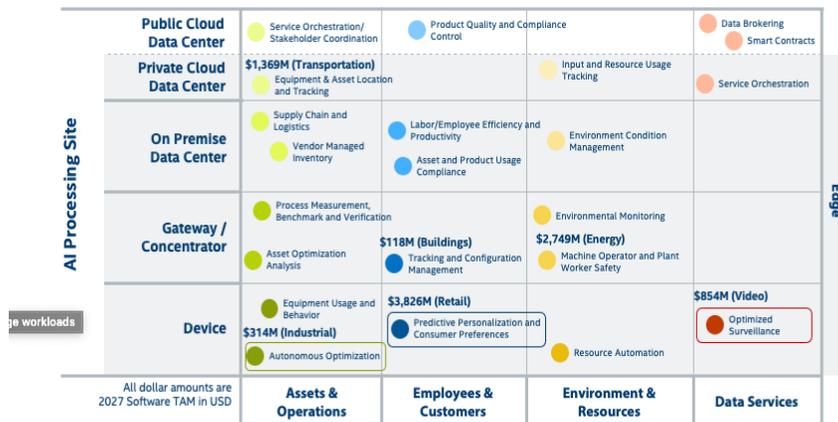
Silicon will grow at a CAGR of 50% while software will grow 64% over the time horizon, indicating that Intel should focus on its core silicon while looking to capture portions of the explosive software growth



TAM By Intel Segment (USD millions)	2018	2023	2027	Relative Mkt Share (Gain/Loss)	CAGR
Energy	\$ 312	\$ 2,698	\$ 16,280	↓	49%
Industrial	\$ 257	\$ 2,621	\$ 17,647	↑	53%
Smart Building	\$ 295	\$ 2,736	\$ 16,184	↓	49%
Gaming & Entertainment	\$ 3	\$ 81	\$ 851	↑	76%
Healthcare	\$ 332	\$ 2,886	\$ 18,609	↓	50%
Office Automation	\$ 52	\$ 415	\$ 2,959	↓	50%
Other	\$ 7	\$ 55	\$ 340	↓	47%
Public Sector	\$ 75	\$ 841	\$ 7,294	↑	58%
Smart Home	\$ 387	\$ 2,380	\$ 11,120	↓	40%
*Video	\$ 148	\$ 1,203	\$ 6,503	↓	46%
Retail Analytics	\$ 145	\$ 1,443	\$ 8,702	↓	51%
Transactional Retail	\$ 10	\$ 114	\$ 991	↑	58%
Visual Retail	\$ 115	\$ 922	\$ 5,702	↓	48%
Transportation - CTL	\$ 241	\$ 2,232	\$ 12,805	↓	49%
Transportation - SDC	\$ 83	\$ 678	\$ 3,409	↓	45%
Transportation - ADAS	\$ 90	\$ 2,184	\$ 24,901	↑	75%

Most valuable use cases are driving edge workloads

Across key verticals, strong areas of opportunity cluster around AI use cases that are best served through edge processing due to the mission- or time-critical nature of the applications



Illustrative Examples:

- Autonomous optimization algorithms for industrial robots run constantly and require real-time sensory and environmental feedback which is best served through edge processing
- In-store retail kiosks and digital signage must respond to customer behaviors in real-time, which is pushing workloads to the edge
- Processing high-fidelity video data across thousands of city security IP cameras is pushing AI deployments to on the physical camera to avoid pressure on city IT infrastructure

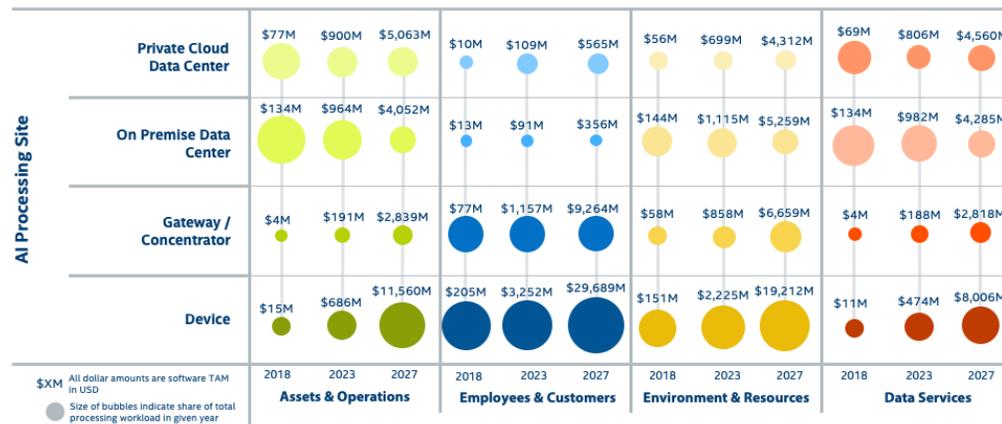
AI revenue opportunities are shifting to the edge

Across key verticals, the share of workload and associated 2023 revenue opportunity of both software and hardware is shifting broadly to edge devices



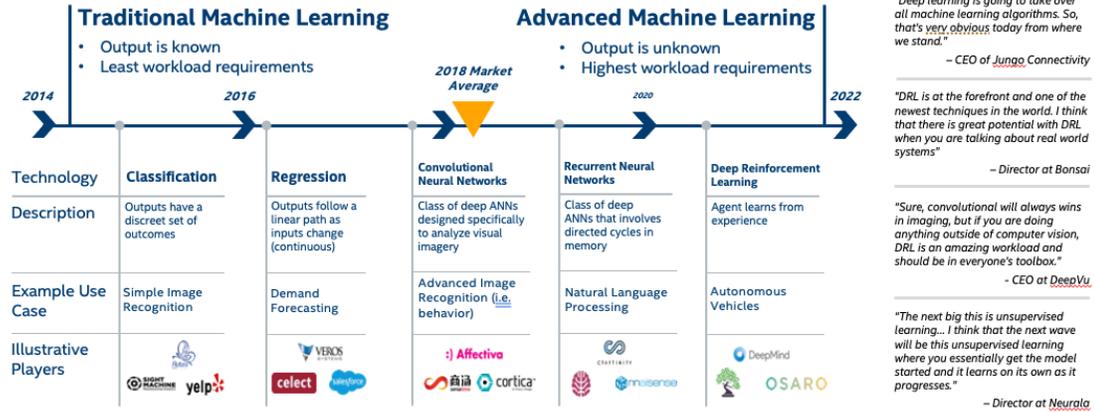
AI application opportunities are shifting to the edge

Across key verticals, the share of workload and associated revenue opportunity of software applications is shifting broadly to edge devices



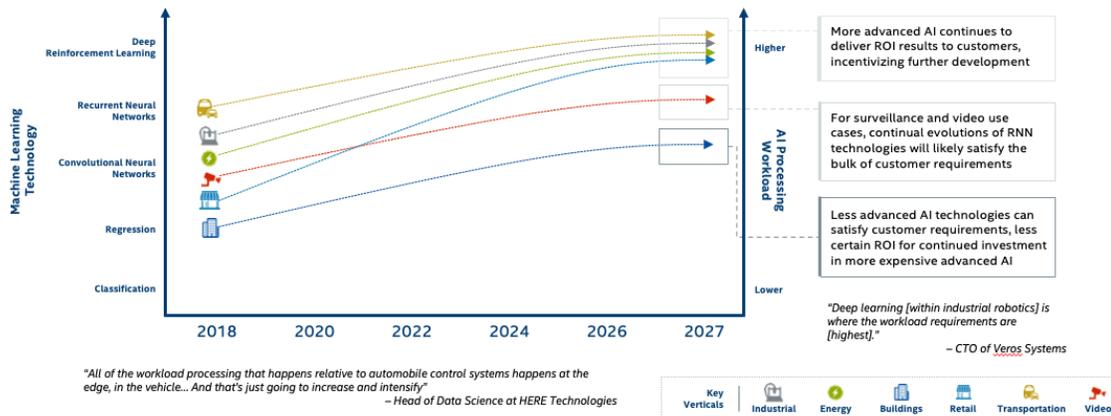
AI progressing from supervised to unsupervised

Continued advancement in software technologies is pushing the market from where a bulk of players are developing today towards more complex unsupervised machine learning



More advanced AI will drive higher workloads

AI processing workloads will increase across all verticals, but will increase most significantly in verticals where more advanced AI technologies can continue to garner ROI for customers



Buildings

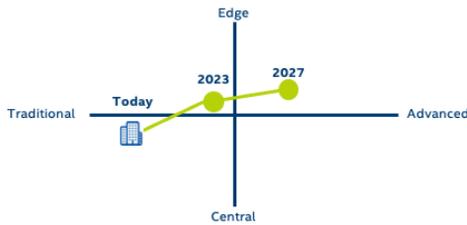
Summary

More conservative in AI adoption than other primary verticals, Buildings currently target AI technologies that optimize energy management

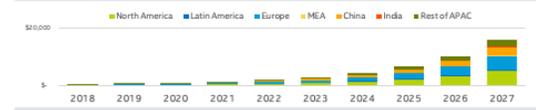
Key Customer Challenges

- AI adoption in Buildings is largely inhibited by a lack of understanding by decision makers of the beneficial impact that AI technologies have on optimizing their buildings' energy management
- Facility managers often lack the technical skill-set to understand how AI/ML technologies can integrate and enhance building equipment and systems.
- Many older buildings do not have the requisite infrastructure to be able to benefit from AI-based technologies

AI Tech Maturity & Processing Location



AI Edge Opportunity & Focus Areas



Top Use Cases

- Energy Management Optimization
- Consumer-Preferred Environments
- Predictive & Preventative Maintenance

Key Devices

- EMS
- BMS
- Lighting Control System
- HVAC
- Fire & Safety
- Security & Access

TAM Revenue Opportunity

	Silicon	Software
2018	\$155 M	\$140 M
2023	\$1,280 M	\$1,456 M
2027	\$6,150 M	\$10,033 M

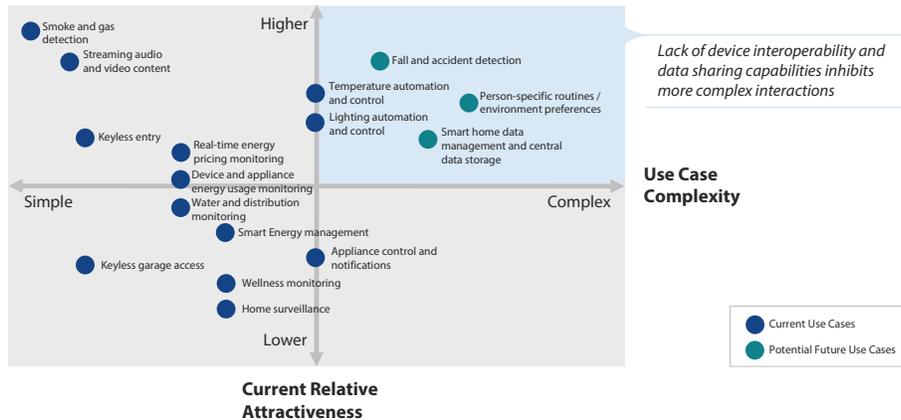
Key Players

Hardware	Software

F1. Smart Home Developer Kit Opportunity Assessment – Selected Slides Below

End Customer Smart Home Use Cases – Today’s Map

Today’s top use cases are fairly simplistic in terms of the complexity of the interactions between devices. In the future, as customers desire applications demanding more complex interactions between devices, interoperability will be paramount



Source: Harbor Research Smart Home and Buildings Occupant Data

6

Client | Harbor Research
April 2017

Key Findings – Smart Home HDK Market Opportunity

[Client] should tailor its HDKs to meet the feature requirements of the top smart home use cases, and position the HDKs towards large home product OEMs

<p>Competition</p> <ul style="list-style-type: none"> The most popular HDKs on the market aren’t targeted towards any specific IoT application, but the few that are targeted at smart home applications tend to target a variety of smart home use cases Most HDKs are modular, meaning that they either come with few or no embedded sensors and the ability to add additional sensors depending on the use case 	<p>Product Positioning</p> <ul style="list-style-type: none"> The most enthusiastic developers for smart home HDKs are developers at large home product OEMs (i.e. Jenn Air, Maytag) Developers generally use HDKs to stand up prototypes to show to stakeholders, not to use in production Prices of HDKs span from \$10 to \$300, with an increase in complexity and application specificity directly correlating with an increase in price 	<p>Market Demographics</p> <ul style="list-style-type: none"> The size of the addressable market of smart devices that could be developed with an HDK is large, with the device base of top use cases in smoke detection, lighting, and appliance control expected to grow by 20-40% over the next 3 years Developers see HDKs as cheap, flexible, and easy ways to stand up connected prototypes without having to acquire or develop the talent and skills necessary 	<p>Addressable Smart Home Devices Shipping in 2017:</p> <p style="font-size: 2em; font-weight: bold; text-align: center;">336 M</p>	<p>Recommendation:</p> <p>Position the HDK as smart home specific, with a combination of embedded sensors and ability to add sensors as needed</p> <ul style="list-style-type: none"> Position the product towards large-scale deployments of connected devices from home product OEMs, touting Intel’s ability to scale custom, high performance chip sets Pricing should be around \$250 for voice-only, and around \$350 for voice and camera <p>Target specific home product OEMs through identifying:</p> <ul style="list-style-type: none"> Top device segment growth rates Maturity of company’s connected device capabilities Potential device install base
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5

Client | Harbor Research
April 2017

'Best in Class' Hardware Development Kits

Survey findings regarding the hardware, software, and support features that different developers are looking for highlight the most potent combination of functionality for [Client's] development kits

	Developing a Smart Home Device – 89% of Responses				Not Developing a Smart Home Device – 11% of Responses			
	Used an HDK		Did not use an HDK		Would use an HDK		Would not use an HDK	
Sensors	GPS, LED as Light, 1 Microphone , Temperature, Body Temperature		Motion Detector, Standard Camera , 1 Microphone , Temperature, Body Temperature		Motion Detector, Standard Camera , 1 Microphone , Temperature, Blood Pressure		GPS, LED as Light, 1 Microphone , Temperature, Blood Pressure	
Connectivity	1. Wi-Fi 2. Cellular 4G/LTE	1. Wi-Fi 2. Bluetooth	1. Wi-Fi 2. Bluetooth	1. Wi-Fi 2. Bluetooth	1. Wi-Fi 2. Bluetooth	1. Wi-Fi 2. Bluetooth	1. Wi-Fi 2. Bluetooth	
Platforms	1. Google Home 2. Amazon Alexa	1. Google Home 2. Amazon Alexa	1. Google Home 2. Amazon Alexa	1. Google Home 2. Amazon Alexa	1. Google Home 2. Amazon Alexa	1. Google Home 2. Amazon Alexa	1. Google Home 2. Amazon Alexa	
Voice Algorithms	1. Amazon Alexa 2. Apple HomeKit	1. Amazon Alexa 2. Microsoft Cortana	1. Amazon Alexa 2. Microsoft Cortana	1. Amazon Alexa 2. Microsoft Cortana	1. Amazon Alexa 2. Apple HomeKit	1. Amazon Alexa 2. Microsoft Cortana	1. Amazon Alexa 2. Microsoft Cortana	
Operating System	Windows 10	Windows 10	Windows 10	Windows 10	Linux	Windows 10 / Linux	Windows 10 / Linux	
Additional Library	Sensor Aggregation	Intercom / Monitoring	Intercom / Monitoring	Intercom / Monitoring	Biometric	Sensor Aggregation	Sensor Aggregation	
Support								

Survey data based on responses from 310 hardware and software developers.

7

Client April 2017 **Harbor Research**

End Customer Smart Home Use Cases – Addressable Device Market

Analyzing which smart home devices associated with top use cases are forecasted to grow fastest offers Intel a clear perspective into which features they should prioritize in their hardware development kits

¹ Top Use Case Ranking:	Connected Device(s) Required:	² Connected Devices Shipped 2017:	³ Connected Devices Shipped 2020:	² 2017 – 2020 Shipped Device CAGR:
1 Smoke and carbon monoxide detection	• Smoke detector • Gas detector	• 90.64 million • 5.86 million	• 252.34 million • 16.32 million	41%
2 Streaming audio and video content	• Televisions & Sound Systems	• 279.43 million	• 450.70 million	17%
3 Temperature automation and control	• Thermostat	• 174.04 million	• 299.35 million	20%
4 Lighting automation and control	• Light bulb • Lamps	• 44.18 million	• 96.19 million	30%
5 Keyless door entry	• Door lock • Video intercom	• 1.37 million	• 2.99 million	30%
6 Real-time energy pricing monitoring	• Energy meter display	• 289.69 million	• 316.88 million	8%
7 Device and appliance energy usage monitoring	• Kitchen: oven, fridge, coffeemaker... • Bath: shower, pipes, water heater	• 5.54 million • 14.40 million	• 11.85 million • 31.36 million	29%
8 Water and air distribution monitoring	• (Gas and) Water meters • HVAC Units	• 289.69 million • 39.68 million	• 361.88 million • 86.39 million	11%
9 Smart Energy management	• Energy meter display	• 289.69 million	• 316.88 million	8%
10 Appliances control and notifications	• Kitchen: oven, fridge, coffeemaker... • Bath: shower, pipes, water heater	• 5.54 million • 14.40 million	• 11.85 million • 31.36 million	29%

⁴Overall Connected Device Growth from 2017 – 2020: **25%**

²New Connected Device Types from 2016 – 2017: **35%**

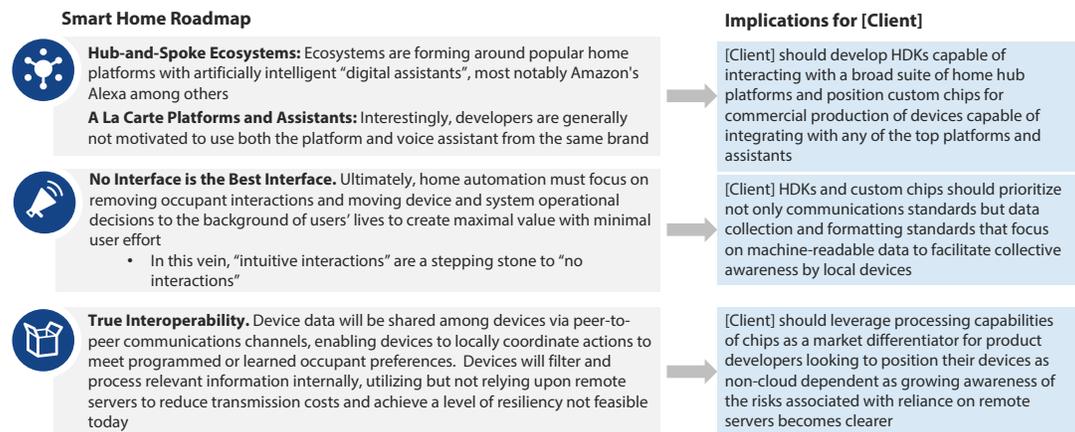
Sources: ¹Harbor Research Smart Home and Buildings Occupant Data
²Harbor Research Smart Systems Forecast Model

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Future Roadmap and HDK Implications

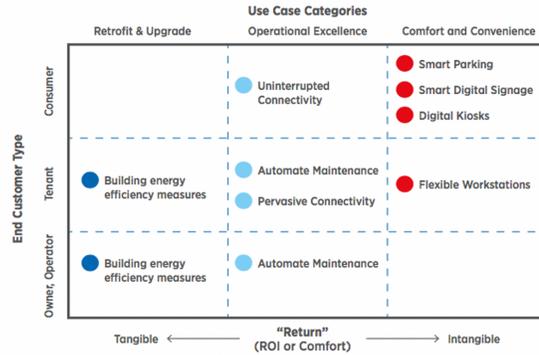
Increasing device-level processing demands create a silicon opportunity in a wide array of connected home products. Prioritizing communications, data interoperability and flexibility will differentiate [Client's] HDKs



F2. CABA 2018 Landmark Research on Intelligent Building Monetization (select outputs below)

Use Case Categories Impact Owner / Operator Decision-Making

- **Retrofit & Upgrade:** Use cases included in this category include those that are predominately energy management related and that have very tangible metrics for measuring the expected return on investment
- **Operational Excellence:** Use cases that still have quantifiable returns but are less tangible than retrofit and upgrade use cases.
- **Comfort and Convenience:** Use cases that don't have objective or clear measures of return for the stakeholder

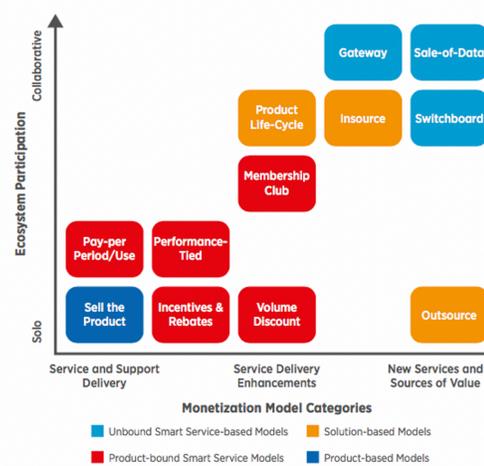


Source: Harbor Research, Combined Survey Data

Example: Retail store customers desire interactive digital signage to enhance their user experience, pushing retail store owners/operators to choose less tangible ROI solutions in hopes that ROI is made up in customer loyalty or other qualitative metrics



Top Use Cases Aligned with Player Types Result in Monetization Model Alignment



Unbound Smart Service:
Device serves as the point of access to other services which are less automated, or which are not sold directly to the device's end-user.

Solution-based Smart Service:
Made possible by customer activity chains that have a total value far in excess of the purchase price of the device.

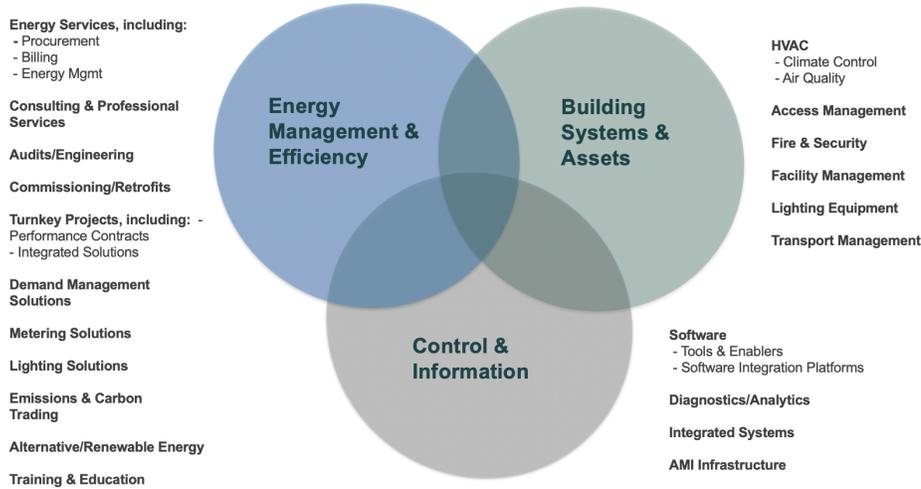
Product-bound:
Revenue is collected not simply for the product, but, in some way, for the associated service.

Product-based:
The embedding of connectivity into the product does not open a great opportunity for selling value-adding services. For these companies, the only revenue model is the same old one, the "one-time transaction" model.

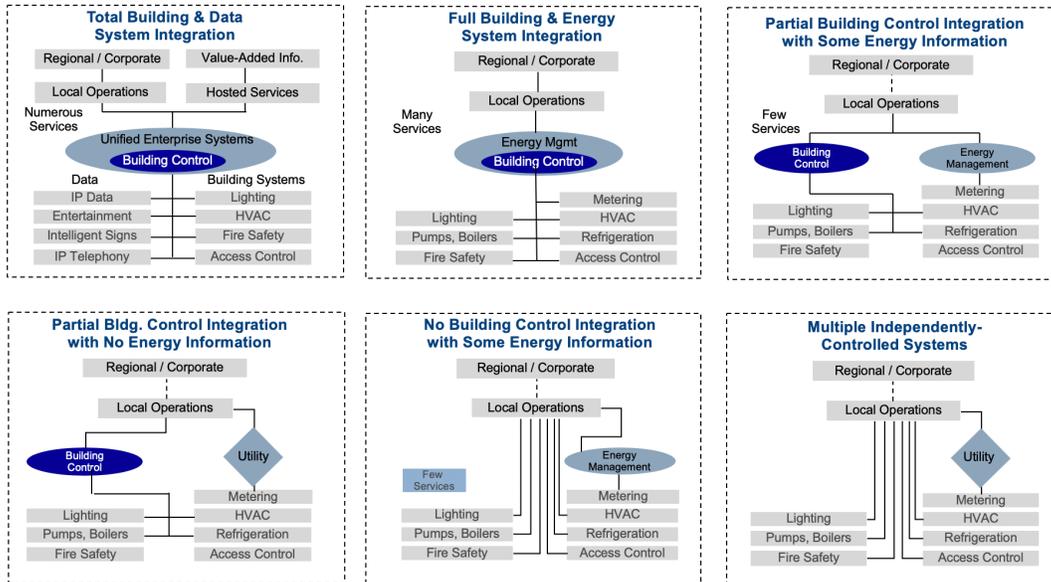


F3. Intelligent Buildings Opportunity Assessment (select outputs below)

Building, Energy Information & Control Convergence ...Some Day



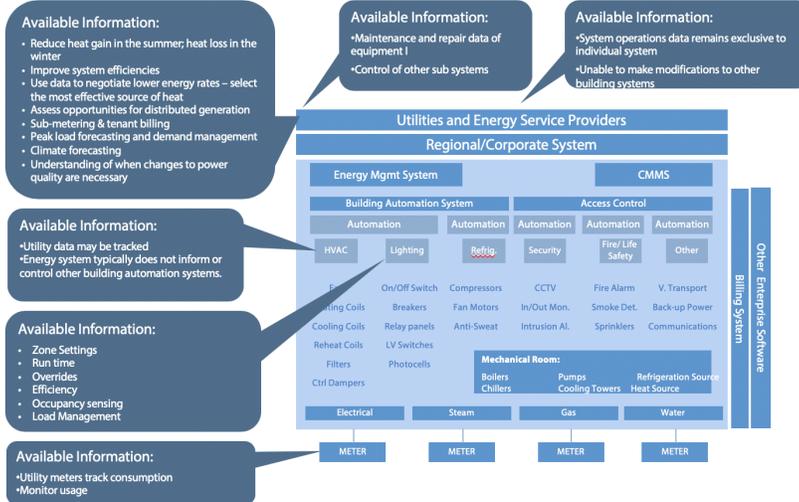
Customer Integration Demands Vary Widely



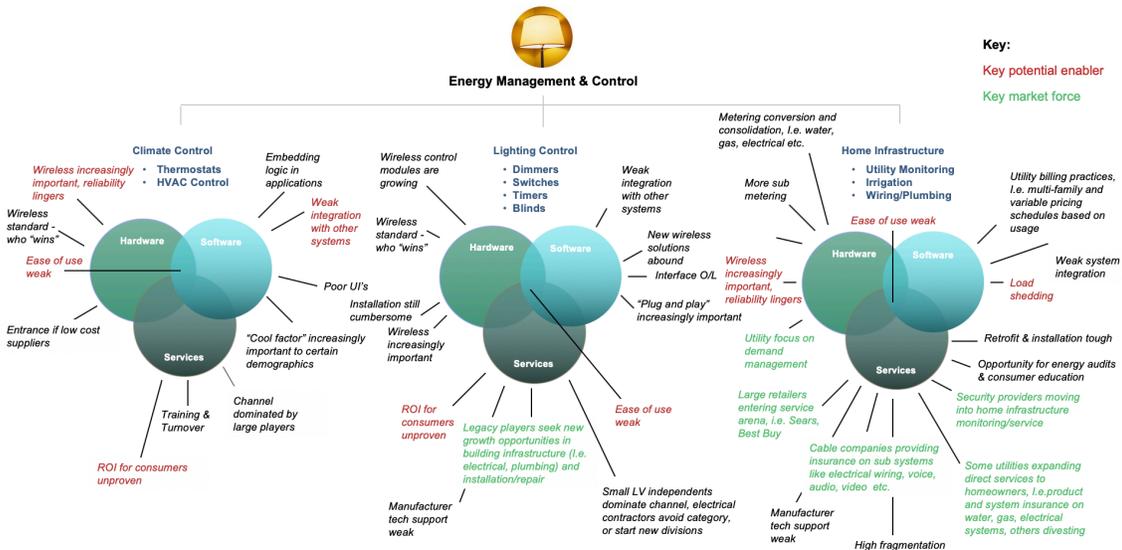
Evolution of Building Information Systems

While there are integrators and system suppliers that can integrate disparate facility & energy solutions
..... few understand how to optimize energy usage and costs...

Synthesizing and acting on the available information is key!



Illustrative Framing of Forces and Trends



Illustrative "Personas" and Behaviors Are Key To Needs & Usage

	 Tech-Focused	 Security-Driven	 Hassle-Free/ Service-Centric	 Cost-Driven
	Strongest needs are ensuring comfort and lifestyle through attractive appliances no matter the cost	Ensuring no service interruptions is a top concern along with cost concerns. Also care significantly about physical and cyber security	Want high degree of service and minimal hassle in choosing, operating and configuring systems	Highly motivated to reduce costs of bills and appliances – want high degree of control to ensure goals are met
Usage Goal	• Comfort and Convenience	• Balance of comfort and cost	• Convenience and Cost	• Cost
Device Profile	• High tech home	• Time saving appliances	• Minimalist	• Time saving appliances
Buying Behavior				
Price Sensitivity	• Low	• Medium	• Low	• Low
Interest in Technology	• High	• Medium	• Medium	• Low
Security Concerns	• Medium	• High	• Low	• Low
Care about Energy & Environmental Impacts	• Medium	• Low	• Low	• Medium

Ecosystem Opportunities and Challenges

