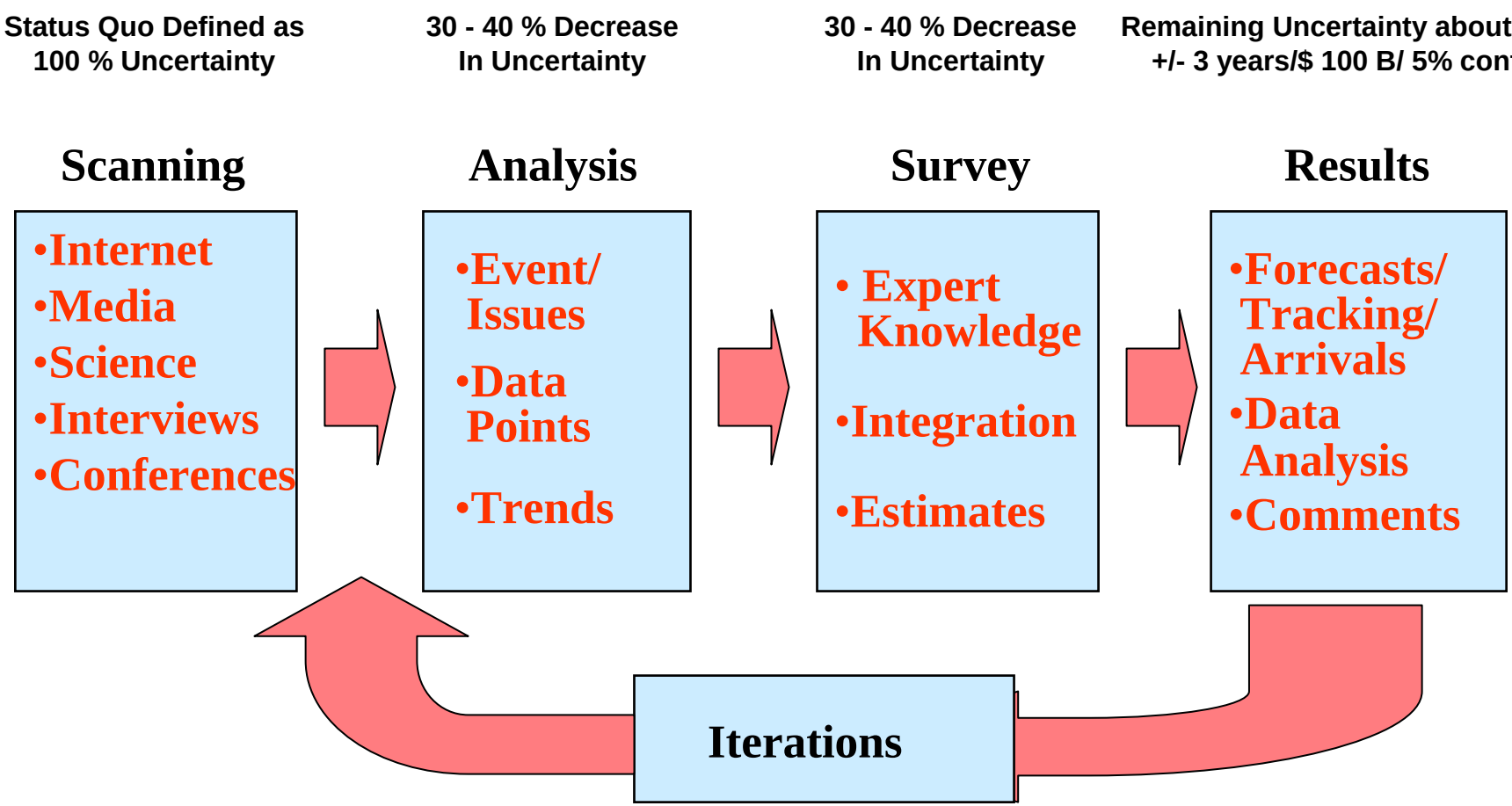
Forecasting
The Technology Revolution

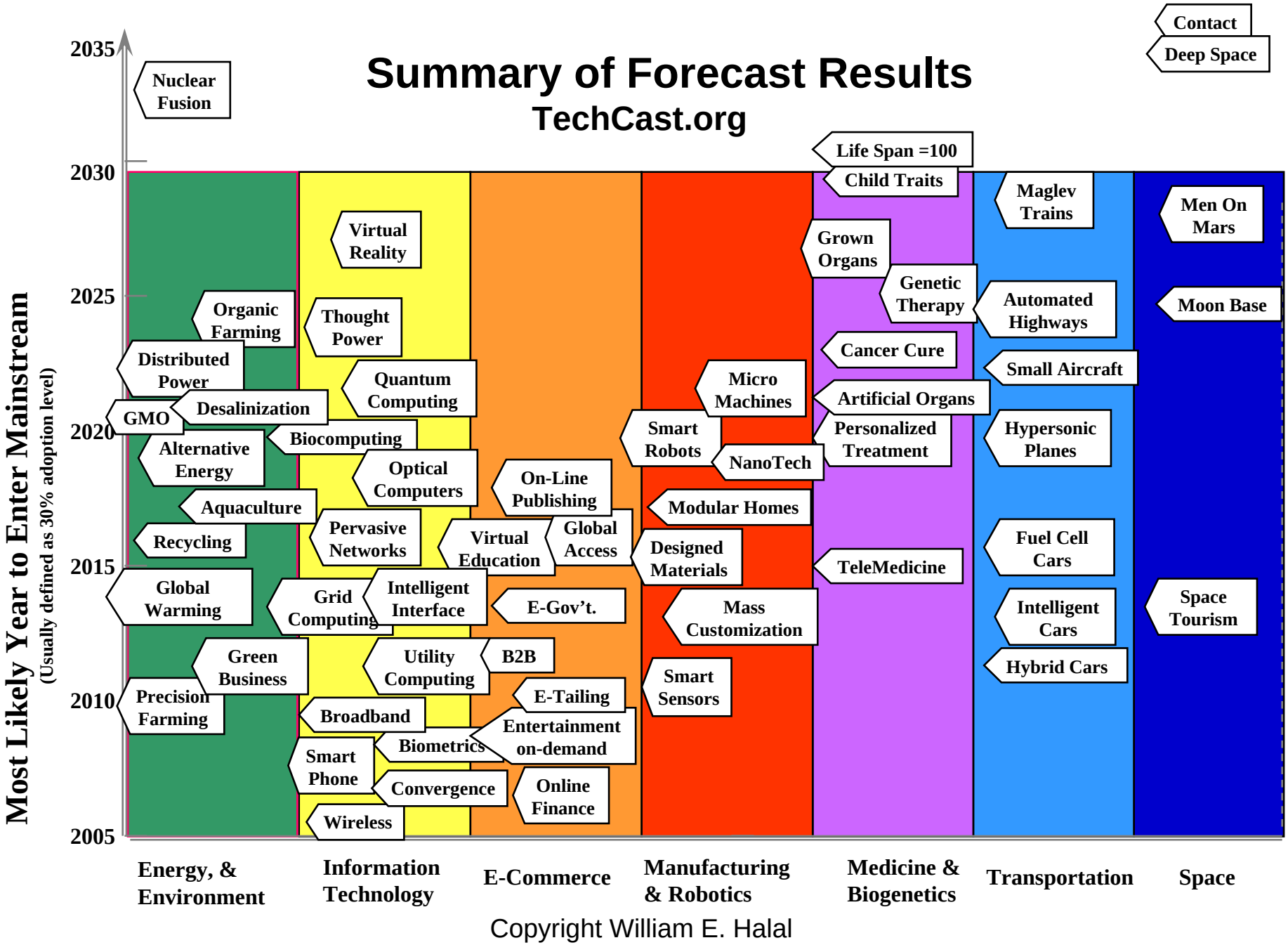
Highlights from the TechCast Project
(www.TechCast.org)

William E. Halal
George Washington University

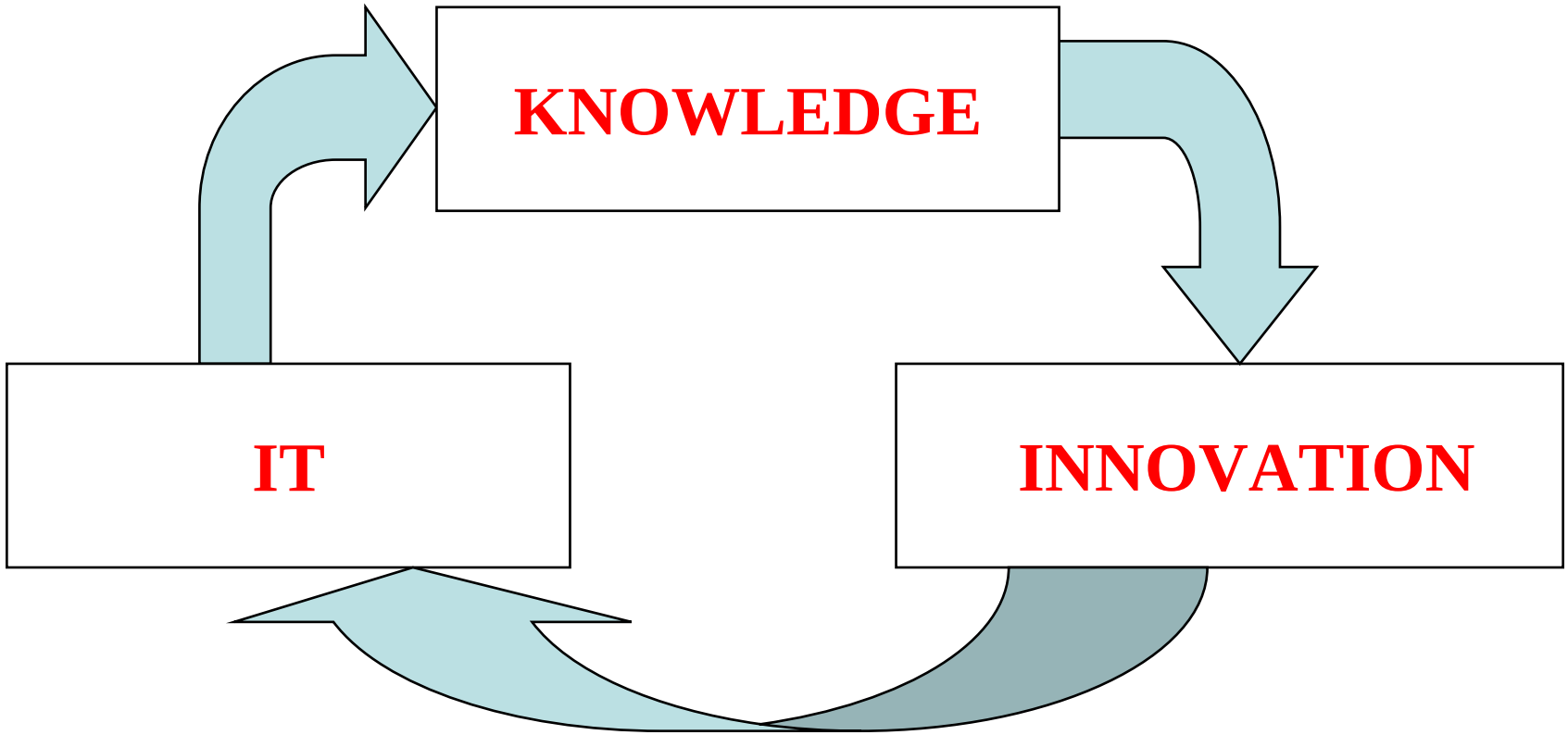
TechCast Online Research System

"Best Possible Answers to Tough Questions"

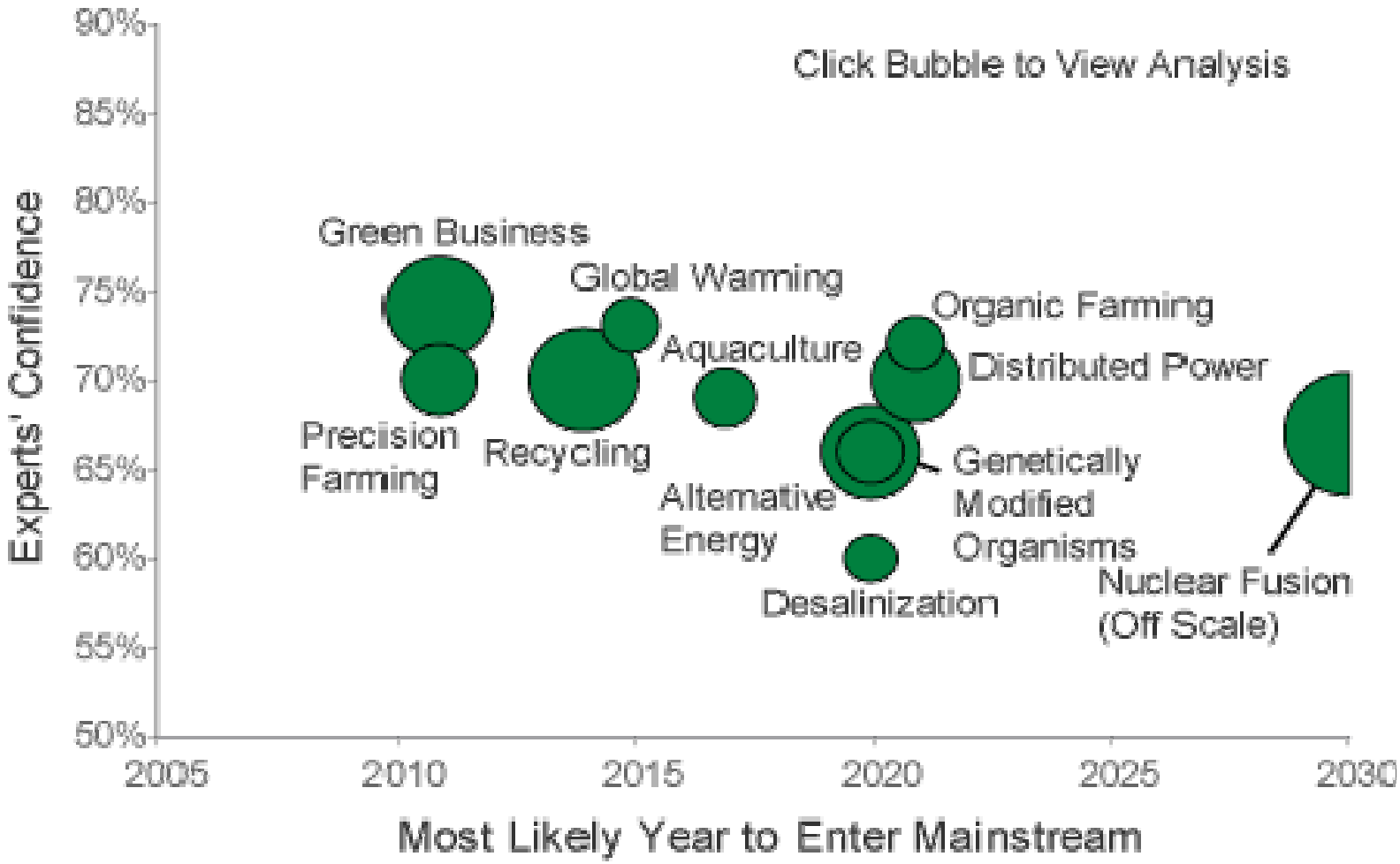




THE VIRTUOUS CYCLE OF KNOWLEDGE



Energy & Environment



Alternative Energy

- Global oil production in decline – Hubert's Peak
- Rising demand/oil prices make alternatives feasible
- Geothermal, wind, biomass competitive now
- Clean coal technologies/sequester CO2 in mines
- Concentrated solar/photovoltaic in 2010/20?
- Hydrogen matures 2010-20?
- Biggest source is conservation (Lovins)
- Nuclear favored - 350 plants to 500-600 by 2010
- Deregulation/distributed energy sources
- TechCast - 30% of energy use: 2020

Distributed Power

- Grid blackouts. “The system was never designed to handle long-distance traffic.”
- Zero energy homes (solar, wind, fuel cells, microturbines, etc.)
- 40 states allow selling power to the grid
- Reduce transmission costs, risk and severity of failures, vulnerability to attack
- TechCast: 30% by 2022
- Analogous to distributed IT, organizations, etc.

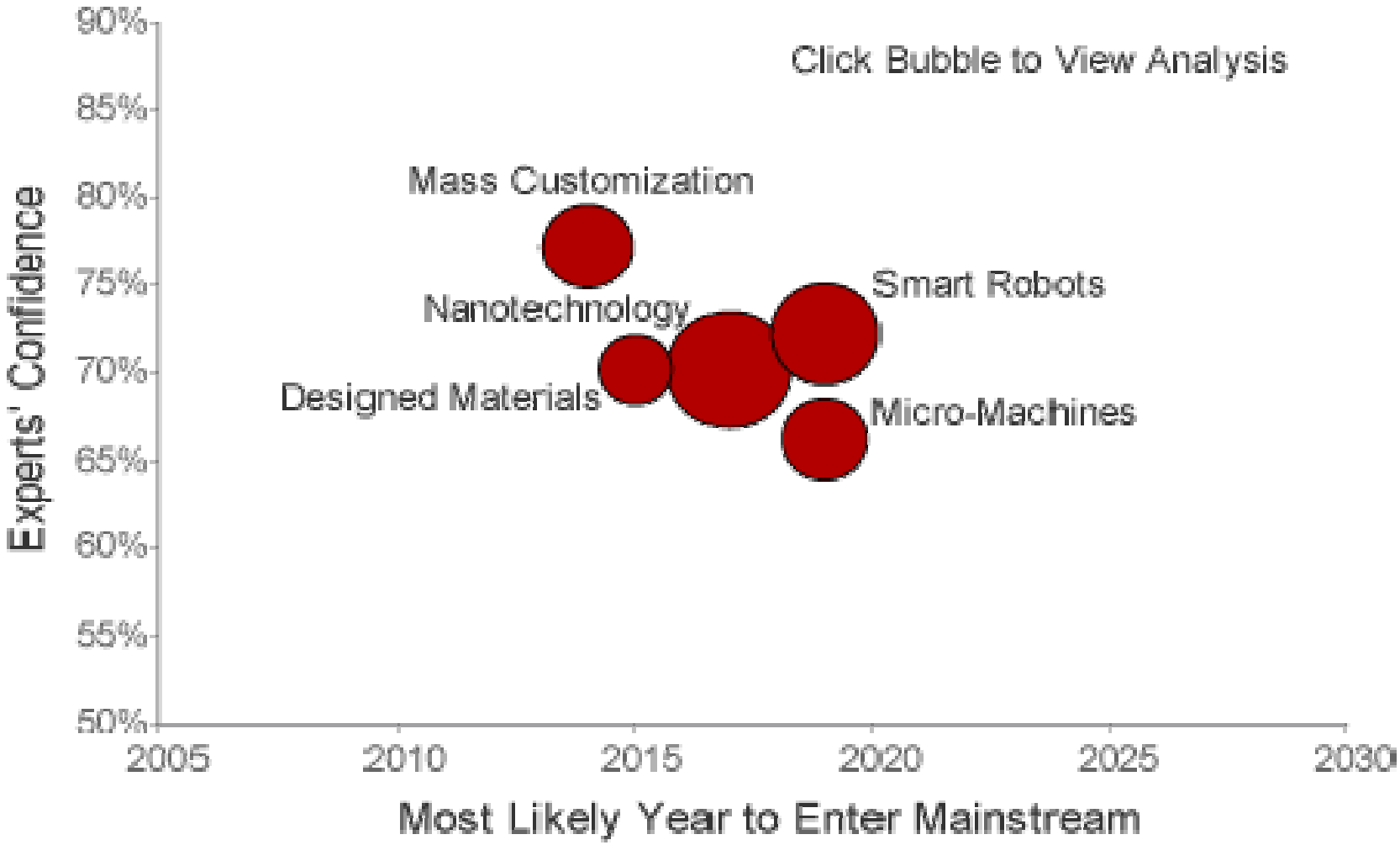
Desalination

- 7,500 plants now operating
- Half of world uses unsafe water
- “Water promises to be in the 21st century what oil was in the 20th century”
- Shift from public to private management
- Reverse osmosis replaced by capactitive deionization, nanotech
- Cost from $20/gallon in '50, to $6/gal. in '60, now approaching 1 cent/gal
- TechCast: 30% by 2021

Precision Farming

- Case, Deere systems about $6000
- Computerized tractor, GPS, GIS
- Huge variations in land
- Optimize fertilizer, pesticides, seed, etc.
- Increase yield, decrease cost and pollutants
- Cause decline of family farm?
- TechCast: 30% of crops by 2013

Manufacturing & Robotics



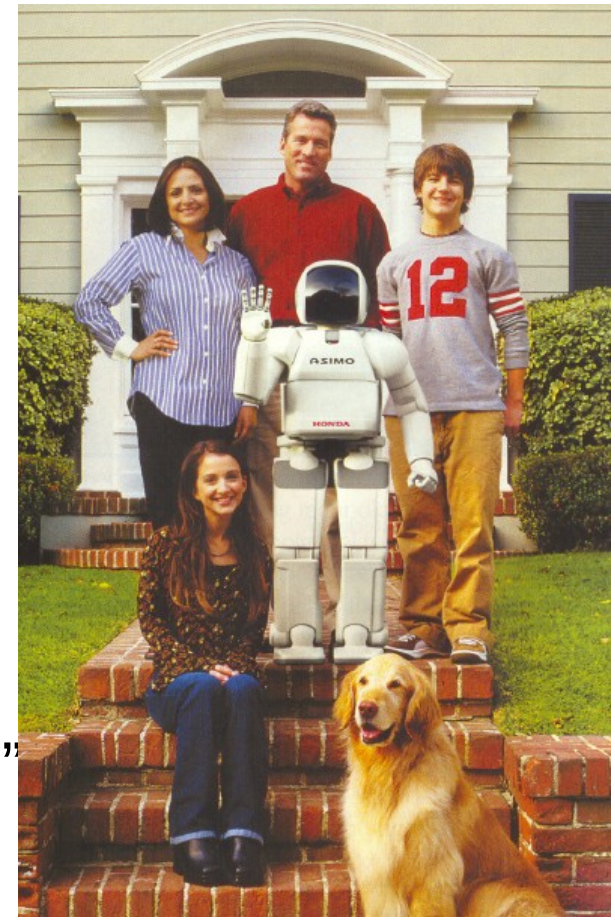
Robotics

State-of-the-Art (Sony, Honda, Toyota)

- 60K vocabulary, speech recognition
- 30 motor joints, walks, runs, stairs
- Pattern recognition (faces, surroundings), learning

Coming

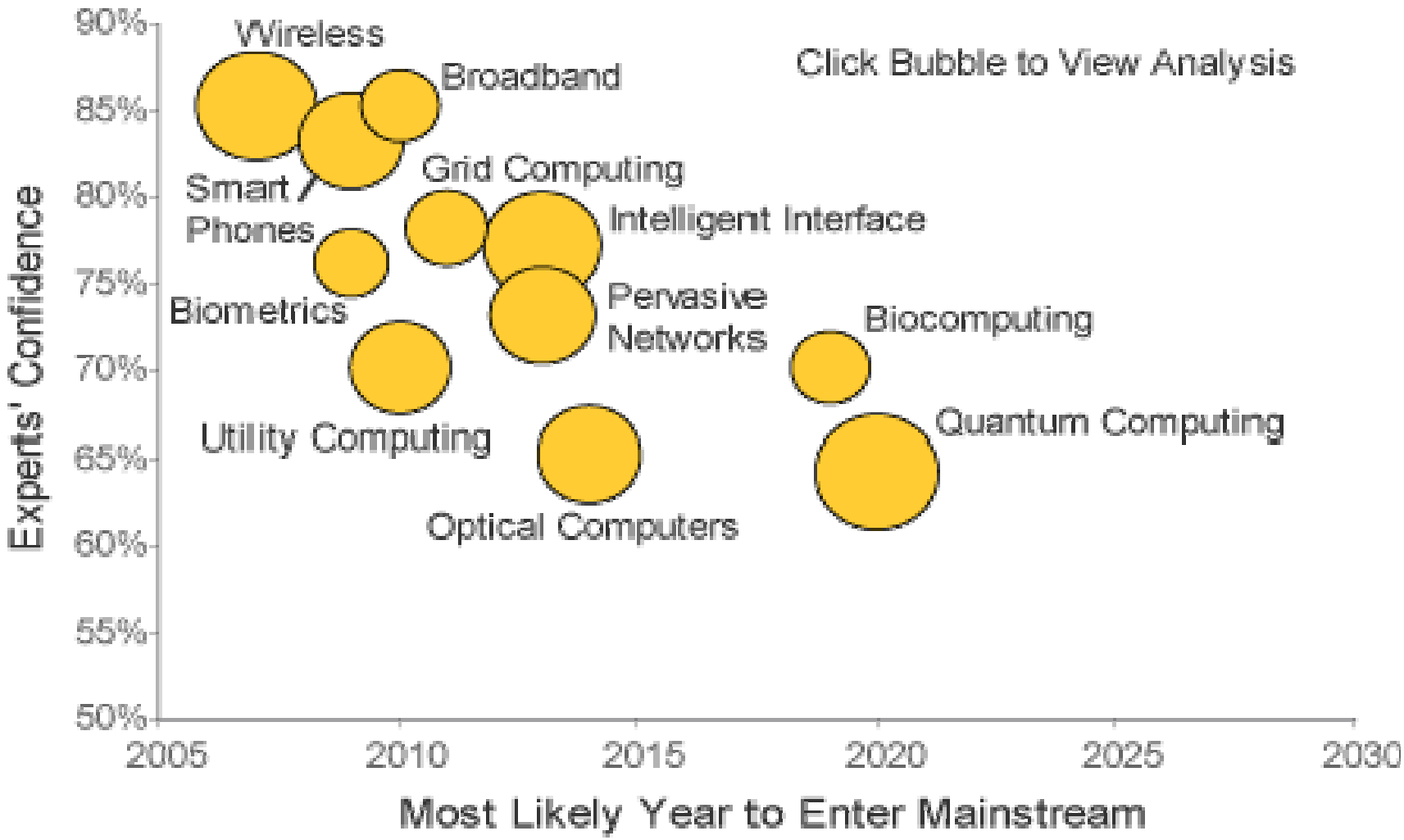
- Emotional interactions – Kizmet (MIT)
- Improved AI, speech, consciousness?
- Care givers, servants, warriors, etc.
- Rodney Brooks (MIT): “Like PCs in ’75”
- TechCast – 30% of homes by 2020



Nanotechnology

- Nano = 1 billionth of meter/10 atoms wide (IBM spelled in atoms)
- Nanotubes/spheres - 100X tensile strength of steel, 1/6 weight, no friction, store energy
- Faster chips, 1 million x data storage (40% by ’11)
- Superconducters 100 X efficiency of copper
- NSF: half of medical treatments
- Space elevator – 1 meter film of nanotubes to geosynchronous orbit in15 yrs. @ $10B
- NSF: $1 trillion market
- 6000 patents, 1200 ventures
- TechCast – 30% of products by 2018 +/- 5 yrs

Information Technology



Biometrics

- Solution to security problem?
- Fingerprints, eye, face, hand, voice
- 35% growth rate/next killer app?
- Implemented by UK, US, EU, Japan
- Fingerprints replace credit cards by ’07
- No perfect solution/“multimodal” systems
- Databases take time to build
- TechCast - 30% of identifications 2010 +/-2 yrs

Wireless

- Growing 60% year
- Wireline decreasing, wireless will dominate
- WiMax – 70 Mbs, entire city.
- EvDO uses cell network
- Ultra wideband – 1 Gbs.
- 10 Gbs by 2008
- Laptops going wireless
- TechCast – 30% of communications 2007

Grid Computing

- Opposite to Utility Computing
- Raise PC usage from 5% to 75%
- Growing 80% year
- Grid systems: Boeing, IBM, EU, UK, etc.
- Security? Cost?
- TechCast – 30% large tasks by 2012

Utility Computing

- Opposite to Grid Computing
- IBM's main strategy – "Workplace"
- Provide power, software, security, etc.
- Most computers use 10-20% of capacity
- H-P, Sun: intraorganizational approach
- Loss of control? Response time?
- TechCast – 30% of computer use 2011 +/- 4

Pervasive Networks

- 4 billion chips used now
- 1 Trillion devices connected in 10 years
- RFID tags
- Nanosatellites
- Smart dust
- Standards for appliances
- Digital home coming
- Loss of control?
- TechCast – 30% of settings by 2013 +/- 3 yrs

Optical Computers

- Now have switches, fiber, CD storage
- 1000 times faster
- Thousands of messages per channel
- Nanotubes can emit light
- Holograms store 1 Terabyte/disc
- Able to store light signals
- Optical processors developed
- Possible successor to silicon
- TechCast – Commercial computer 2014 +/- 3 yrs

Quantum Computing

- Infinite power & storage (Superimposition allows 1 electron to carry 2 qubits, 2=4, 3=8, 20 = 1 M bits)
- Entanglement permits teleportation
- Prefect cryptography – Harvard
- Memory, switches developed
- Possible successor to silicon
- TechCast -commercial computer 2021 +/- 5

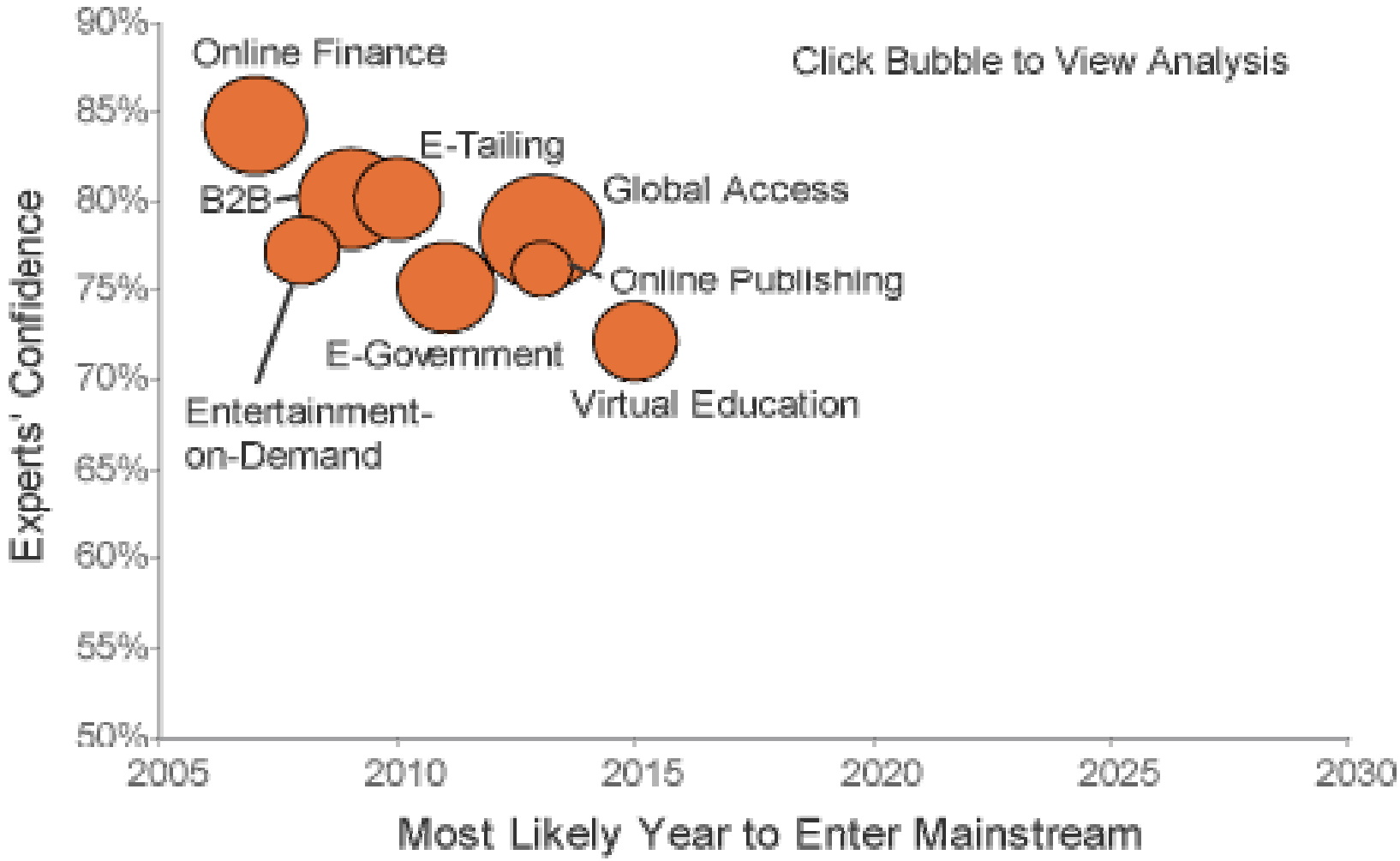
Thought Power

- Skull caps, implanted electrodes detect brain signals
- Wireless control of PCs, machines, communications, wheelchairs, etc.
- Military remote control of weapons
- Chips implanted in 1 M dogs and cats, 1000 people; Prof. Warwick wired to PC, wife
- Electronic eyes, hearing, etc. - bionic person
- Sony able to control sight, sound, taste, etc.
- Artificial limbs controlled by thought
- NTT labs uses skin to transmit signals
- Freman Dyson forecasts of “radiopathy”
- TechCast – commercial use 2021 +/- 9 yrs

Virtual Reality

- Growing 30% year
- Useful for testing designs, surgery, training, visualize data, meetings, courtrooms, sports, etc.
- Improving: BB, wireless, AI, power, etc.
- Movies going 3D
- Yahoo has 7 M users on VR sites (avatars, etc.)
- Google etc. storing images of everything (cities, Mars)
- DoD developing 6 ft moving holographs
- Japan: virtual TV (3D, touch, smell) by 2020
- Augmented reality, telepresence, etc.
- UCLA, There, Pompeii, war, museums
- TechCast - 30% of people 2016 +/- 4 yrs

E-Commerce



Broadband

- 30% homes in US/70% S. Korea
- 50% by 2010
- Verizon – 30 Mbs
- Japan – 10 Gbs
- Wirless – 70 Mbs
- Internet II – 7 Gbs
- High bandwidth applications?

The Intelligent Interface

Good Speech Recognition Common about 2010

- IBM, Microsoft, MIT, DARPA programs to complete in 2010
- 50% of firms use speech call centers, 100% will soon
- Google/Yahoo use voice recognition search systems
- GM's OnStar has 2 million subscribers, growing 1-2 million/year

AI Able to Learn and Makes Decisions about 2015-20

- IBM developing autonomic computers that manage themselves
- Robot development
- DARPA program developing hypersmart computer that learns and adapts
- BCC study of AI market: $1 B in '93, $12 B in '02, $21 B in '07
- Bill Gates: "The future lies in computers that talk, see, listen, and learn"

Flat Wall Monitors Common by 2010

- Flat monitors beat CRTs. Dell: "Ultimately, the flat panel is less expensive."
- Waldorf Astoria Hotel uses 4x7 Ft monitor for videoconferencing

PC Power Supports Intelligent Systems

- Intel and AMD have brought out first 64 bit processors
- The Cell has 9 128 bit chips

The Intelligent Interface (cont.)

Virtual Robots/Avatars Common about 2010

- Dozens of examples – Ananova.com, Cobot-ATT, UK's Virtual TV Guide
- **"**There**"** is a 3D multimedia virtual environment with Avatars
- CEO of Native Minds: "The Internet will be filled with robots by 2010"

Other Support for Intelligent Interface

- UCLA Virtual Reality Lab – a "time machine" of ancient Rome
- Robots – 60 K word vocabulary, dance, walk up stairs, etc.
- IDC: "What the GUI was in '90s, the natural user interface will be this decade."

Obstacles

- Cynicism about AI is strong
- Mistakes & frustration will remain

TechCast – 30% of tasks by 2013 +/- 5 yrs

TeleLiving

Technology Gap – End of the Keyboard/GUI Interface?

- Dumb PCs, sales flat at 60%, 90% think IT too complex
- Webphone with a 2x2 inch monitor and keypad?

Coming of the “Intelligent Interface”

- Speech recognition about 2010
- AI about 2015
- Flat wall monitors about 2010
- Adequate PC power about 2005
- Virtual robots about 2010
- Heads-up display for mobile use about 2010

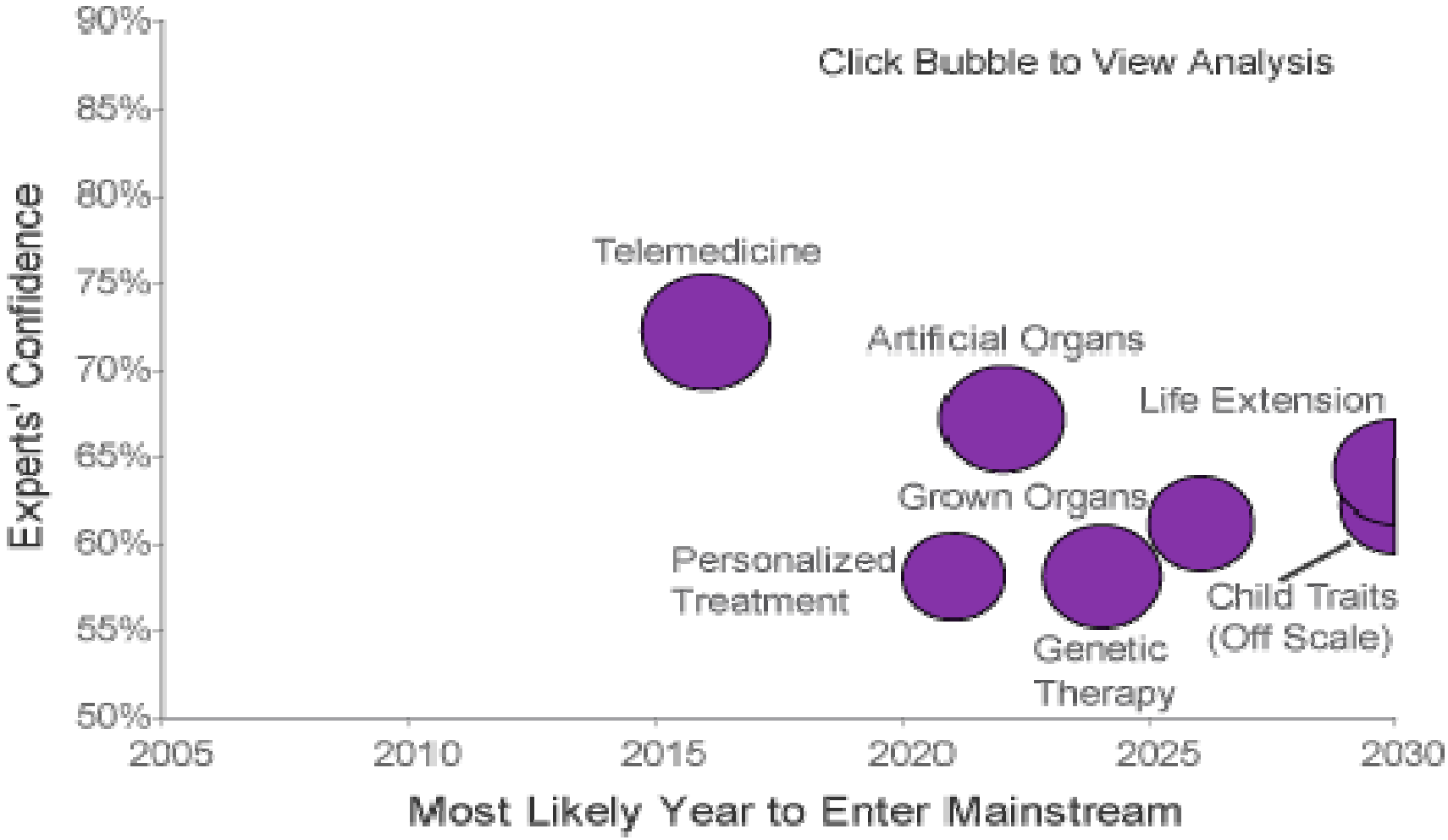
From TelePhone, to TeleVision, to TeleLiving

- Comfortable conversation with life-like figures
- All social functions: work, shopping, education, medicine, etc.

Applications of TeleLiving

- Voice call centers
- Virtual website salesperson
- Voice control of computer, TV, appliances
- Dictation, voice messaging
- Video conferencing & collaboration
- Virtual assistant
- Electronic tutors
- Virtual doctor, lawyer, mechanic, etc.
- Multimedia/virtual reality experiences

Medicine & Biogenetics



Telemedicine

- 90% of medical tasks use paper/phone
- US medicine $1.7 trillion/16% of GDP Could be cut by 20-50%
- Resistance by physicians, administrators, patients
- Point of care terminals/records/PDAs
- Publication of patient outcome data
- Remote patient monitoring/video conferencing
- Prescription management
- Non-invasive/robotic surgery
- Interactive IT models of the body, each patient/smart cards
- Computerized diagnostics
- Self-care management/knowledge management
- National Medical IT Czar, Kaiser Permanente – “inevitable”
- Forecast: 2014

Artificial Organs

- Now: joints, veins/arteries, blood, heart valves, tendons, pacemakers
- Motorized intelligent arms and legs
- Eye cameras with chips
- Neuromodulators (brain/spinal implants like pacemakers) for Parkinson's, seizures, migraine, etc.
- Permanent Heart – 2010
- Kidney – 2015
- TechCast – replace major body parts by 2020
- Advant./disadvant. with real organs ?

Child Traits

- Sex selection well-developed
- Prenatal screening
- Height/hair color/IQ etc?
- Little public support
- Gov’t prohibitions – UK
- Social norms change
- TechCast – 30% of parents by 2032

Cancer Cure

- Roughly 50% death rate. Now dropping
- 10 drugs in ’95. Now 400
- 90 detection treatments
- Human Cancer Project to identify mutations
- Molecular biology – RNA/dendrimers to deliver drugs. DNA used to alter genetics
- Nanotubes to identify and destroy cells
- Cancer stem cells identified for destruction
- TechCast – Life spans approach normal by 2023

Genetic Therapy

- 5000 genetic disorders
- Successful trials - but also deaths
- 300 companies working on 500 trials
- Virus used to carry DNA
- DNA placed in cells
- Zinc fingers - amino acid that corrects DNA defects
- Genes injected into heart
- Public demands cures
- TechCast – Cure 30% of disorders by 2023

Grown Organs

- Huge need: 150K organ shortages, 300K spinal cord damage, 1 million Parkinsons, 5 million heart damage
- Stem cells created from skin/adult cells
- Brain cells created from stem cells
- Some mice have genes that regenerate organs
- Genes discovered that make stem cells pluripotent
- Immortal supply of bone, skin, stem cell cultures
- Repaired jawbone, nose, ear, heart, spinal cord
- Coming: liver, heart, fingers, etc.
- TechCast: Major body parts by 2027

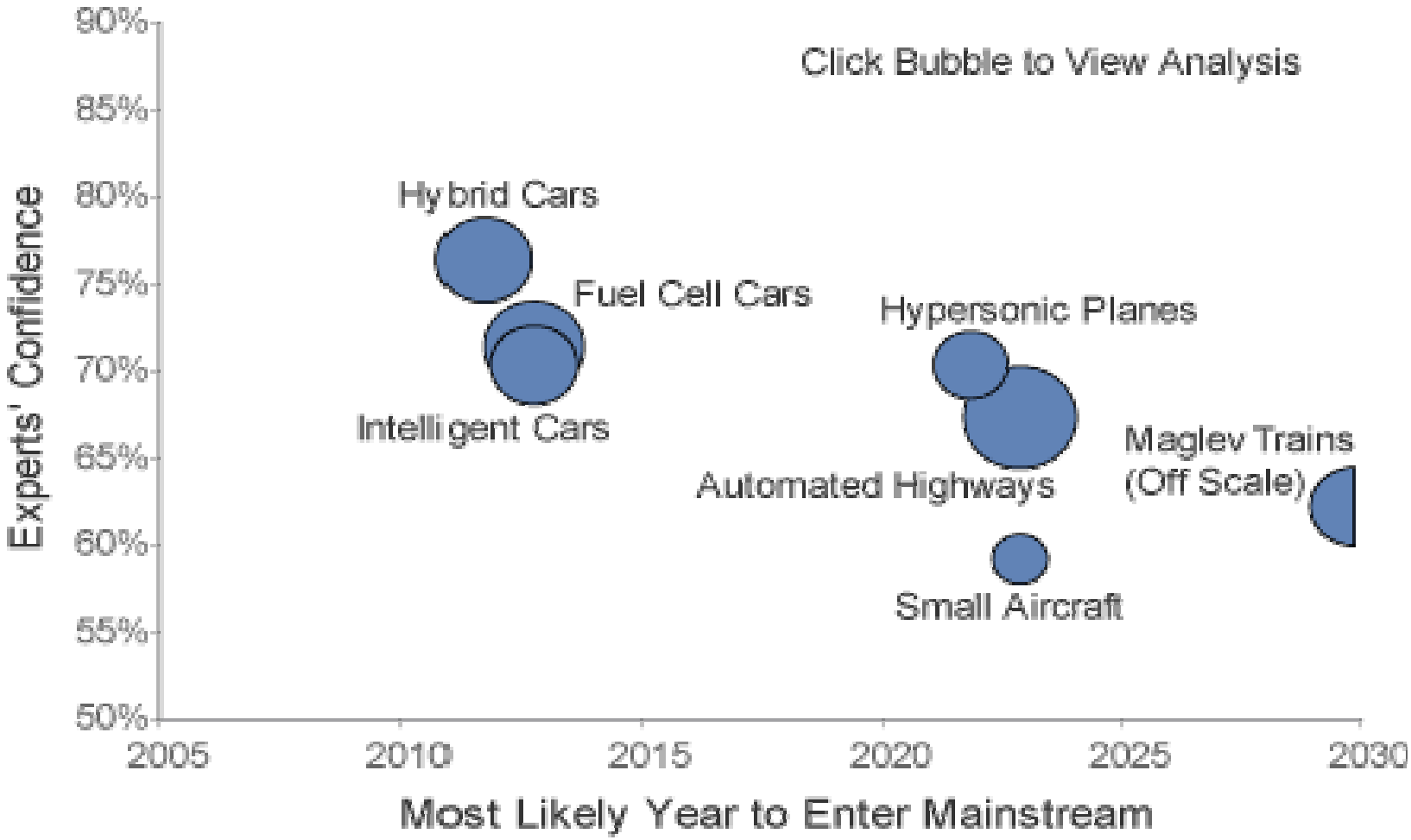
Personalized Treatment

- Staggering complexity
- General treatment 40-50% effective, side effects, 100K deaths/year
- Some DNA testing now; $1000 by ’10
- Companies working on projects
- Catalog of genetic variations published
- Would ease drug development
- “Framework for future of medicine”
- TechCast – 30% of treatments by 2018

Life Extension

- Improved lifestyles/alternative medicine
- Hormone replacement ?
- Organ replacement
- Telemeres, enzymes, genes, etc. extend life
- Nanotech, micro-medicine to repair the body
- Kurzweil, de Grey: all causes of aging curable
- Some claim life spans are genetically fixed
- CEO of Human Genome Sciences: “We can conceive of immortality”
- TechCast - 100 years avg. span by 2037

Transportation



Hybrid/Fuel Cell Cars

- Hybrids – 30% new cars by 2015
  - Toyota, Ford, GM, etc.
  - Fuel efficiency, clean
  - Regenerative braking
  - Composite plastic bodies
  - Solar panels?
  - Flywheels?
- Fuel cells introduced – 2013
  - 250 approaches being developed, including China
  - Infrastructure needed
  - Economics?

Intelligent Cars

- Costs of congestion - 5 B lost hrs, $50 B lost prod., 40K deaths/$150B
- Traffic to double by 2020
- GPS, OnStar, navigation, cruise control, collision-avoidance, electronic tolls, etc.
- Used in Europe, Japan
- Infrastructure required
- Taiwan: the next $ trillion industry
- TechCast – 30% of cars by 2014

Automated Highways

- Cost of traffic congestion
- Automation increases capacity x 2-3
- Cost/mile = $10K vs. $1-100M new roads
- Can improve safety, fuel eff., pollution
- Technology available
- TechCast - 2024

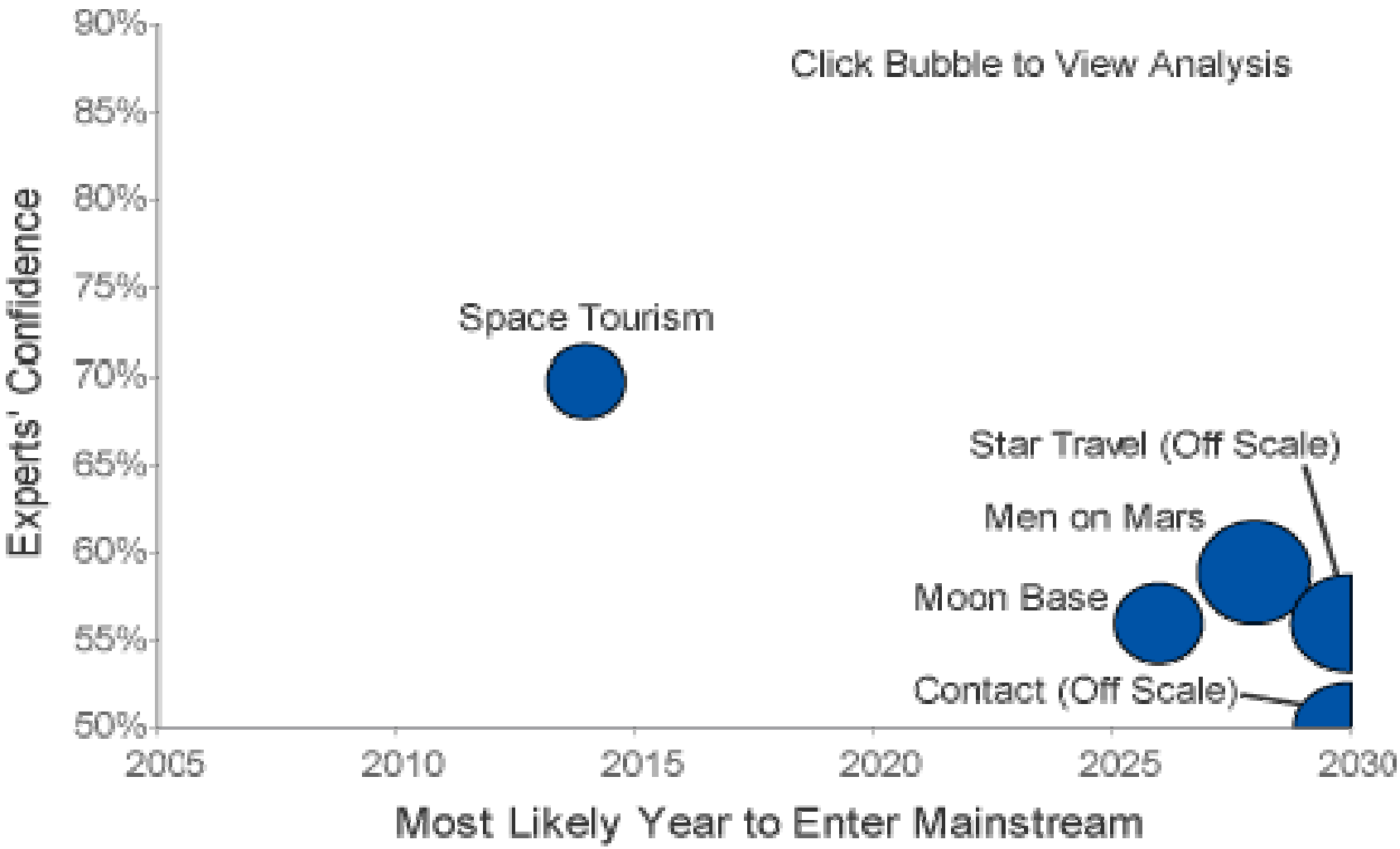
Hypersonic Planes

- US, EU, Australia, and Russia testing Mach 10 scramjet planes
- Aerospatiale Matra - 2015
- Demand caused by globalization
- Reduce flights to Asia from 30 to 3 hrs
- TechCast – 30% of long flights 2028

Maglev Trains

- 300 MPH, replace short air travel
- DC to NYC 1 hour
- High investment, lower operating costs
- Energy efficient, low pollution, comfort
- UK, Japan, Germany dropping projects
- China, US adopting projects
- TechCast – major cities by 2033

Space



Space Tourism

- Shuttle flights (Tito), Space Ship One, Virgin Galactic
- Space Adventure Co. has 1000 clients interested in going to the Int'l. Space Station for $20 M and **around the moon for $100 M** between 2008 and 2010.
- Robert Bigelow - $500 M cruiseship
- Market surveys (10,000 people @ $1 M)
- NASA – 2010-12
- TechCast: “Spacecruiser carries tourists in high orbit around Earth” – 2014

Moon Colony

- Part of US Mars Plan, EU Mars Plan
- Close, resources, water
- 1/6th Earth gravity, biosystems ???
- Development projects underway
- NASA – 2018, EU Project Aurora ?
- TechCast - 2028

Men on Mars

- Full year of travel, radiation, other obstacles
- Development projects underway (Nuclear propulsion, biosystems, launch rockets, etc.)
- NASA forecast – 2020
- TechCast - 2030

Contact

- 130+ planets discovered – virtually
- Telescopes, radios improving (Moore's law)
  - NASA's Terrestrial Planet Finder
  - James Webb Space Telescope 2.5 times the size of Hubble, orbit 1.5 million K above Earth.
  - The Allen Telescope Array consists of 350 telescope dishes
  - The European Space Agency flotilla of 7 spacecraft orbiting precisely to form a giant mirror telescope array
- Odds of intelligent life – 10k-100k advanced civilizations in milky way alone
- Pulsars (cycling bursts of light) signs of intelligence?
- NASA scientist: "In the next 20 years we'll find the habitable planets within 100 light years from Earth."
- TechCast - 2079

Deep Space Travel

- Nearest star 40 years 1-way
- Life support/Biosphere experiment
- NASA Advanced Concepts Program
- Breakthroughs in physics needed
- Michael Griffen, NASA: “A single planet species will not survive. One day there will be more people living off of Earth than on it."
- Global Project?
- TechCast - 2069

A New Paradigm in Physics?

- NASA"s "Breakthrough" program (warp drive, wormholes)
- Light can be stopped and accelerated
- Universal constants in physics have been changing
- Time travel – possible in theory
- Control of gravity – waves measured
- Models of the universe (cyclic, expansion, etc.)
- Structure of the galaxies
- Visible stuff (4%), dark matter (23%), dark energy (73%)
- Role of spirit (astronauts, etc.)