Open Innovation in the Eighteenth Century

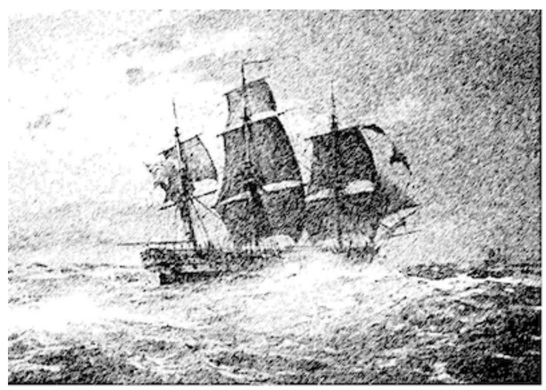
The Longitude Problem

Robin W. Spencer

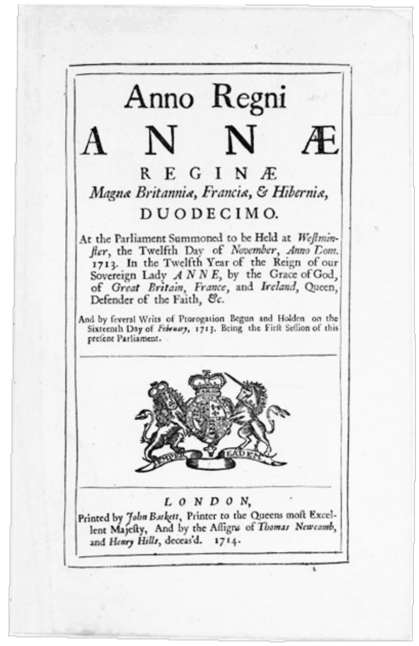
Overview: Forget Linux, Netflix, DARPA, and the X Prizes. Deliberate, managed open innovation goes back 300 years. At that time, the determination of longitude at sea was both vitally important and apparently impossible; so having failed with a team of experts, Parliament sought solutions from a wider field via the Longitude Act of 1714, which offered a prize of £20,000 for a method of determining longitude to within 30 miles, to be proven on a voyage from Britain to the West Indies. The Act established a Board of Longitude to manage submissions, decide upon the prize, and, if necessary, grant additional money to support an inventor's progress. The *process* created for the administration of the Longitude prize remains as relevant today as any modern prize-based example.

Keywords: Open innovation, Innovation prizes, Longitude prize

On the night of October 22, 1707, a fleet of Royal Navy warships was homeward bound in wind and rain. Far off course, they struck the rocks of the Scilly Isles off the coast of Cornwall, losing four ships and 2,000 men in one of history's greatest naval disasters. This tragedy was to spark the first great open innovation challenge—one that still has powerful lessons for innovation in the twenty-first century.



The fundamental problem for the hapless commander of the fleet, Admiral Sir Cloudesley Shovell, and for Britain, which depended on mastery of the seas for security and trade, was that it was very difficult to know the longitude of a ship at sea. Latitude (distance north or south) was easily found by the angle of the North Star or noonday sun over the horizon. Determining one's longitude—east-west position relative to an arbitrary zero point—was far more difficult. The ancient Greeks knew that the spherical earth made a full rotation per day, and therefore finding longitude was equivalent to knowing simultaneously the local time and the time at the reference point. Local time was easy to find by sun sighting; the problem hinged on knowing the time elsewhere. Accuracy mattered: at the equator, the speed of the earth's rotation is about 1,040 miles per hour or 17 miles per minute; at the latitude of London, it is 11 miles per minute. Even if the required sun sighting were perfect, a timepiece in error by a minute would produce this much error in position. All of this was well understood at the time of the disaster, and there had been serious attacks on the problem going back to Galileo. In Britain, King Charles II had founded the Royal Observatory in 1675 for the explicit purpose of addressing the longitude problem, but there had been no useful results nearly 40 years later. Many considered the accurate determination of longitude on a moving ship to be impossible.


Anno Regni
ANNÆ
REGINÆ
Magnæ Britanniæ, Franciæ, & Hiberniæ,
DUODECIMO.

At the Parliament Summoned to be Held at *Westminster*, the Twelfth Day of *November*, *Anno Dom.* 1713. In the Twelfth Year of the Reign of our Sovereign Lady *ANNE*, by the Grace of God, of *Great Britain*, *France*, and *Ireland*, Queen, Defender of the Faith, &c.

And by several Writs of Prorogation Begun and Holden on the Sixteenth Day of *February*, 1713. Being the First Session of this present Parliament.

LONDON,
Printed by *John Baskett*, Printer to the Queens most Excellent Majesty, And by the Assigns of *Thomas Newcomb*, and *Henry Hills*, deceas'd. 1714.

But the Scilly Isles disaster could not be ignored, and so Parliament took a new approach with the Longitude Act of 1714. Enacted in the name of Queen Anne on behalf of the Admiralty, the Longitude Act offered a prize of £20,000 to whoever could produce a practicable method of determining longitude to within 30 miles, to be proven on a voyage from Britain to the West Indies. The Act established a Board of Longitude to manage submissions, decide upon the prize winner, and, if necessary, grant additional money to support an inventor's progress.

The Act attracted the attention of John Harrison, a 21-year-old carpenter and clockmaker from Yorkshire who, with his father, had been making wooden pendulum clocks. Pursuing the prize, he realized that pendulums were infeasible on a rolling ship so he developed a system of balanced springs as the oscillating heart of his timepieces. He presented the Board with his brass and steel H1 model in 1736, which might have sufficed to win the prize. However, Harrison was a perfectionist and asked only for funds to continue improving his invention. Two £500 grants, two models, and 23 years later, Harrison produced the remarkable H4, the first true marine chronometer. The H4 resembled a large pocket watch and incorporated the newest technologies and several Harrison inventions: hardened steel springs, an automatic rewinder, diamond pivots, and a bimetallic temperature compensator. It was more than accurate enough to win the prize. As Dava Sobel (1995) vividly relates, Harrison suffered years of delay, jealously, and obstruction, but finally, with personal support from the King, he was vindicated and over his lifetime received £23,065 from Parliament. He lived long enough to hear Captain Cook sing his invention's praises after using it to map the South Pacific.

The Longitude Act resulted in the invention of the marine chronometer, which solved the problem the Act sought to address. But the Act *itself* was also an important invention: the well-defined, goal-oriented, open innovation challenge. Chronometers and sextants may be museum pieces today but the Longitude Act remains highly relevant as the invention of a *process*. Every aspect of the Act holds lessons for innovation challenges today, establishing best practices that every modern organization should consider:

- **Clearly define the strategic importance of the initiative**. Even though the Scilly Isles tragedy was fresh in memory, the Act reminds the reader of the pressing need for better navigation to save lives and property, encourage commerce, benefit the Royal Navy, and bring honor to the kingdom. The potential contributor need not ask "why should I bother?"

- **Establish high-level sponsorship**. The Queen, Parliament, and the Admiralty are all named in the act as sponsors of the effort. Contributors could have confidence that submissions would be received seriously, and that meritorious solutions would be implemented and broadly applied as quickly as possible. Nor should anyone doubt that the reward, however huge, was credible.

- **Define the desired outcome**. The goal is very simply stated: the determination of longitude to within half a degree or 30 miles. In fact, the Act sets different prize amounts for accuracies of 30, 40, and 60 miles**.**

- **Provide for testing and verification.** The Act provides a clear measure for success: the method must achieve the stated accuracy on a voyage from Britain to the West Indies. Everyone would understand this to be a realistic test with no control over weather, duration of the voyage, or even the skill of the person conducting the test. This stipulation excludes astronomical methods which require clear skies and stable, careful observations.

- **Establish a review team.** About half of the Act is taken up with establishing a Board of Longitude, naming its members, and spelling out rules and responsibilities. The Longitude Act even provides for diversity in the board's membership, striking an effective balance by including technical expertise (the Realm's best scientists), those with direct responsibility for testing and implementation (plenty of Admirals), and political authority (members of Parliament and aristocrats). By specifically naming the appointees, the Act makes them responsible to the public for fair decisions and results. Among the members was Sir Isaac Newton, then 71 years old and the president of the Royal Society, who had been consulted beforehand on the state of the art and prospects for success.

- **Provide for wide distribution of information about the effort.** Royal proclamations were typically printed in at least a thousand copies and distributed to the sheriffs of counties and towns, who would post them (Brigham 1911). We know that the Act was widely distributed simply by the fact that John Harrison responded to it from the rural hamlet of Barrow-upon-Humber in the north of England, very far from London, Oxford, or Cambridge.

- **Offer a meaningful reward.** In government or corporate R&D departments, researchers are salaried while the organization absorbs the risk that goals might not be achieved. But in a winner-take-all challenge, the risk of failure is borne by the contributors, who will have to devote unpaid time to the quest and absorb production costs for prototypes. Therefore the prize (and any interim grants) must be sufficient to induce talented people to take such risks, because for some it may mean turning away from conventional employment. Certainly £20,000 sufficed in 1714, when annual wages were £13–£30 (Williamson 1982). The Act wisely offers lesser prizes for less accurate solutions, and even some money for attempts that don't make the grade at all. Recent evidence suggests that this an important part of reward structure, to spread risk and promote diverse solutions: a single-winner prize may bias toward a precise but conservative approach, while healthy second and third prizes elicit more radical, less certain attempts (DiJusto 2006).

- **Strive for brevity and simplicity.** Even in the florid language of the time, the Act is only 1200 words long, just two or three single-spaced pages. By comparison, just the legal terms at Innocentive (not including information about any particular challenge) weigh in at 2860 words.[1]

- **Open the effort to the widest field possible.** The Act specified only that the reward be offered to "Such Person or Persons as Shall Discover the Longitude at Sea." There was no restriction in participation by rank, privilege, education, nationality, or gender. Harrison was in fact a self-educated commoner.

- **Don't suggest or exclude particular solutions**. The Longitude Act set forth a simply stated goal with no mention of any specific method or solution that might lead to success—or any discussion of solutions that should be avoided. It did not matter that the Royal Observatory had failed to deliver an astronomical solution. It did not matter that Newton had implied to the Parliamentary authors of the Act that a timepiece of sufficient accuracy might not be feasible (Brewster 1855). Rather, the Act left the field of possible solutions entirely open, and potential contributors free to pursue their own divergent ideas.

Stories of challenges tend to be heroic and compelling: Harrison and the Longitude problem, Lindbergh and the solo crossing of the Atlantic (yes, he did it for prize money). But challenges have been minor contributors in the history of innovation; Morgan (2008) struggles to come up with more than a handful of significant advances resulting from challenges. In any comparison of results, the continuously funded R&D laboratory wins hands down—consider Edison's Menlo Park, Bell Labs, NASA, and the combined experience of the aerospace, pharmaceutical, and semiconductor industries. By comparison, external challenges seem to be a tool of last resort, to be employed if all else fails or to fill in the gaps in an organization's mainstream innovation pipeline.

Still, the challenge approach is worth our attention today. John Seely Brown and John Hagel (2005) note that ever since Alfred Sloan, corporations have been dominated by a "push" approach to innovation: problems are identified and prioritized and resources are assembled and pushed at the problem by management, with an emphasis on control and efficiency. This is fine if the world is predictable, controllable, and stable over the time it takes to do all that analysis and organization. But what Gary Pisano (2006) says about the pharmaceutical-biotech sector applies nearly everywhere now: businesses can survive and thrive only by mastering complexity, uncertainty, and an ever-increasing speed of change. Seely Brown and Hagel's alternative to "push" is "pull," in which uncertainty

1. See Innocentive's *Solver Terms of Use* at https://www.innocentive.com/ar/contract/view

reigns, participation is open, control is decentralized, and the emphasis is on innovation rather than control or efficiency. The challenge model is tailor-made to support “pull” innovation in a tight global economic climate and the internet age:

- Challenges have a simpler and less expensive “supply chain” than in-house R&D. Just as manufacturing has gotten more efficient by supply chain management, a challenge can be run “just in time” without continuous support for an R&D department.
- “Push” puts financial risk on the organization which has to maintain R&D that may or may not produce desired outputs. “Pull” removes that risk by paying out only upon demonstration that goals having been achieved. The marketplace will put a price to that risk-removal: a proven solution will cost more than a preliminary one. But when cash is tight and uncertainty high, pull becomes more attractive.
- Pull is more agile and responsive. Push cycles of R&D analysis, goals, and funding are typically annual, while a challenge can be drawn up and launched at any time to address a sudden need or opportunity.
- Business is truly global. Challenges can be run at a global scale or targeted at an emerging market in a faraway place, thereby tapping into opinions, culture, and knowledge far from the company’s home office. Note that a challenge does not have to be about a difficult technical problem; it can be as simple as asking for people to write an essay about what they think of your new clothing styles in exchange for discount coupons.
- With the internet, communication has become essentially free, and importantly it is direct-to-contributor and independent of hierarchy.
- The precedents are there: not just for DARPA robot vehicles and X Prizes, but in Proctor and Gamble’s overt reliance on outside knowledge for its innovation pipeline (Huston and Sakkab 2006).

Notice all the echoes of the Longitude story: important problems, insufficient in-house R&D, previously unknown expertise found by far-reaching yet direct communication, cost deferred until a solution is proven. The only aspect of the Longitude challenge that doesn’t fit today is its time scale. It took forty years to realize that the Royal Observatory wasn’t going to solve the problem, a crisis, and another fifty to achieve the H4 chronometer and begin moving it into production. Keep all of the other lessons (sponsorship, purpose, measurables, review process, sufficient reward), speed things up twenty-fold, and the Longitude Act of 1714 stands as a model for challenge-based open innovation in the twenty-first century.

References

Brown, J. S., and Hagel, J. 2005. From push to pull: The next frontier of innovation. *McKinsey Quarterly* 3, August. https://www.mckinseyquarterly.com/Strategy/Strategic_Thinking/From_push_to_pull_The_next_frontier_of_innovation_1642?gp=1.

DiJusto, P. 2006. Winner takes all: Are tech prizes the best way to the cutting edge? *Scientific American* 294(2), February: 25. http://www.scientificamerican.com/article.cfm?id=winner-takes-all.

Huston, L., Sakkab, N. 2006. *Connect and Develop: Inside Procter & Gamble's New Model for Innovation*, Harvard Business Review, 84:3, March 2006, 58-66.

Morgan, J. 2008. Inducing innovation through prizes. *Innovations* 3(4): 105–117.

Pisano, G. 2006. *Science Business.* Cambridge, MA: Harvard Business School Press.

Readers interested in John Harrison and the Longitude Act can find a number of interesting resources online and in print:

Betts, J. 2006. *Time Restored: The Story of the Harrison Timekeepers and R.T. Gould, "The Man who Knew (Almost) Everything."* Cambridge, England: NMM & Oxford. Extracts available as "John Harrison (1693–1776) and Lt. Cdr Rupert T. Gould R.N. (1890–1948)" at http://www.rmg.co.uk/upload/pdf/Gould-Harrison-longitude-JBetts.pdf.

Brewster, D. 1855. Chapter XXI. *Memoirs of the Life, Writings, and Discoveries of Sir Isaac Newton, vol. 2*. Edinborough. Reprinted in Iliffe, R., and Mandelbrote, S., *The Newton Project*, http://www.newtonproject.sussex.ac.uk/view/texts/normalized/OTHE00082.

Brigham, C. 1911. *British Royal Proclamations Relating to America 1603-1783.* New York: Burt Franklin, viii. http://books.google.com/books?id=Y1HERbRKEboC&pg=PR8

Harrison, J., Maskelyne, N. 1767. *The Principles of Mr. Harrison's Time-Keeper, with Plates of the Same.* London: W. Richardson and S. Clarke. http://www.christies.com/LotFinder/lot_details.aspx?intObjectID=5216963

O'Donnell, J. 2002. John Harrison and the longitude problem. *Royal Museums Greenwich Astronomy Fact File*. http://www.rmg.co.uk/harrison.

Siegel, J. 2009. Law and longitude. *Tulane Law Review* 84(1): 1–66. http://docs.law.gwu.edu/facweb/jsiegel/publications/Longitude.pdf. The Longitude Act itself is reprinted on pp 64–66.

Sobel, D. 1995. *Longitude*. London: Fourth Estate.

Williamson, J. 1982. Great Britain: Nominal Annual Earnings for Various Occupations in England and Wales. *The Marteau Early 18th-Century Currency Converter.* http://www.pierre-marteau.com/currency/indices/uk-03.html.