Technological and scientific intelligence in the Elizabethan era.
How to achieve an accelerated technological catch-up

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England's strategy during the Renaissance was to unify the British Isles and protect them with its navy[1] . This was expressed by the adage *"Britain's best bulwarks are her ships' wooden walls".* This strategy had several advantages:

- exporting the destruction of wars out of the national territory;
- developing international trade. The English explorer Sir Walter Raleigh said *"Whosoever commands the sea commands the trade; whosoever commands the trade of the world commands the riches of the world, and consequently the world itself";*
- controlling communications between enemy Spain and its Flemish provinces[2].

Key technologies to conquer

However, England's naval technology gap with the Venetians, Spaniards, and Portuguese was serious[3], especially in the key areas of cartography, navigation, shipbuilding, and cannon making. Catching-up was imperative but difficult because this knowledge was considered as a state secret and was seriously protected[4].

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[1] *"Cecil's long-term goal was a united and Protestant British Isles, an objective to be achieved by completing the conquest of Ireland and by creating an Anglo-Scottish alliance. With the land border with Scotland safe, the main burden of defence would fall upon the Royal Navy, Cecil proposed to strengthen and revitalise the Navy, making it the centerpiece of English power."*
https://en.wikipedia.org/wiki/William_Cecil,_1st_Baron_Burghley

[2] N.A.M. Rodger, *The Safeguard of the Sea: A naval History of Britain,* Penguin Books, 1997, p. 195.

[3] Adam Max Cohen, "Tudor Technology in Transition" in *A Companion to Tudor Literature*, Kent Cartwright, 2010.

[4] Paul J. McKittrick, *Modernity and the spirit of the sea. Maritime influences on early modern English state institutions and society, 1485-1763,* PhD Thesis, School of History and Sociology Georgia Institute of Technology May 2018, pp. 25, 35, 192.

Cartography

Good nautical charts were essential for upgrading from coastal navigation to deep-ocean travel. Elizabeth I and her ministers knew that it was impossible to establish colonies in the Americas without accurate maps. Around 1550, English cartography was primitive[1]. It was not until the 1570s that maps were published or that globes were built in England. When the pirate and explorer Francis Drake prepared his trip around the world, he had to go to Lisbon to buy maps[2]. The greatest cartographers were in Spanish Flanders together with the best craftsmen who knew how to finely engrave copperplates for printing presses[3].

Copperplate engraving for printing a map of the city of London.
Probably engraved in Holland between 1553 and 1559. [4]

Navigation techniques

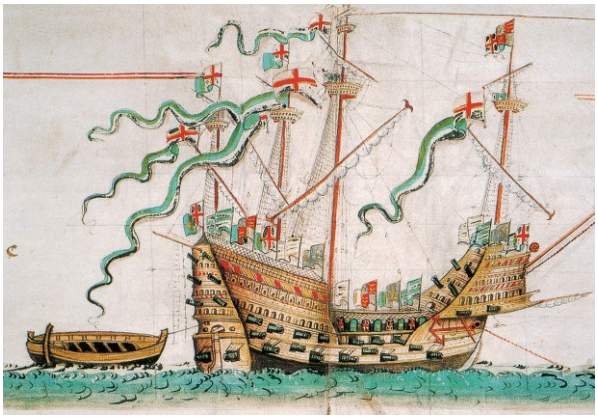
In 1536, following the schism between the Church of England and Rome, king Henry VIII sold off the monasteries. Their libraries were destroyed or dispersed. Critical sciences to navigation such as cosmography, astronomy, and mathematics, were considered to be occult and condemnable magical practices[5]. In 1555, the scholar John Dee was arrested and accused of "calculating" the horoscopes of Queen Mary Stuart and Princess Elizabeth.

Astrolabe dated 1326, similar to the one described by Chaucer,
British Museum. [6]

[1] Eric H. Ash, *Power, Knowledge and expertise in Elizabethan England,* John Hopkins University Press, 2004, p. 74.
[2] David Buisseret, *The mapmakers' Quest. Depicting new worlds in Renaissance Europe,* Oxford University Press, 2003, p. 103.
[3] Daniel Boorstin, *The Discoverers,* Random House, 1985, p. 272.
[4] https://en.wikipedia.org/wiki/File:Copperplate_Map,_Museum_of_London_1.jpg
[5] Benjamin Woolley, *The Queen's Conjurer. The science and magic of John Dee, adviser to Queen Elisabeth I,* Henry Holt, 2001, p. 12.
[6] https://commons.wikimedia.org/wiki/File:Chaucer_Astrolabe_BM_1909.6-17.1.jpg

Naval architecture and shipbuilding

The English *Navy* was practically non-existent at the beginning Tudor kings' era. King Henry VIII (reigned from 1509 to 1547), father of Elizabeth I, made it one of his priorities. He created its first permanent administrative structure (the *Navy Board)*, established royal shipyards and navigational schools, planted oak forests for construction, and built deep-water fortified ports[1]. However, English ships were inferior to Spanish and Portuguese galleons.



Carrack Mary-Rose[2] . circa 1546.

Metallurgy and cannon building

At the beginning of his reign, King Henry VIII was obliged to import almost all his cannons[3]. They were made of bronze, cost a fortune, and were decorated like works of art. Iron cannons were cheaper, much heavier, and less reliable, because they frequently exploded, killing their operators. England did not have copper mines for manufacturing bronze, but it had many iron mines. Developing the technology of cast-iron cannons was therefore an imperative.

Bronze cannon of ship Mary Rose[4] .
Reign of Henry VIII

[1] Eric H. Ash, *op. cit.*
[2] https://commons.wikimedia.org/wiki/File:AnthonyRoll-2_Mary_Rose_cropped.jpg
[3] Nicholas Canny, *The origin of Empire,* Oxford University Press, 1988, p. 86.
[4] https://commons.wikimedia.org/wiki/File:Mary_Rose_Bronze_Cannon_(5695923338).jpg

Scientific and technological intelligence techniques

The contribution of intelligence to this technological catching-up was essential. This article presents its exceptional methods and results, which enabled the British Navy to dominate the oceans for three centuries.

Our goal is to identify methods for accelerated technological catching-up from an intelligence perspective. We have chosen to present them in order of increasing implementation difficulty rather than chronologically or by application domain. A word of caution here! Some techniques are illegal and of course, we do not recommend them!

Asking the Right Questions: The Intelligence Plan

The first step in the *Intelligence Cycle*[1] is asking the right questions. This set of questions is also called *Key Intelligence Topics*[2].

In 1553, the English recruited the Spanish chief pilot Sebastian Cabot for his technical expertise. Cabot advised the navigator Sir Hugh Willoughby on a voyage of maritime discovery of the Northeast Passage to China. His instructions were: *"The names of the people of every Island, are to be taken in writing, with the commodities, and incommodities of the same, their natures, qualities, and dispositions, the site of the same, and what things they are most desirous of, & what commodities they will most willingly depart with".* Cabot recommended keeping a detailed logbook of all hydrographic, naval and astronomical data : *"Daily write, describe, and put in memorie the Navigation of every day and night, with the points, and observation of the lands, tides, elements, altitude of the sunne, course of the moon and starres, and the same so noted by the order of the Master and pilot of every ship to be put in writing, the captaine generall assembling the masters together once every weeke (if winde and weather shal serve) to conferre all the observations, and notes of the said ships, to the intent it may appeare wherein the notes do agree, and wherein they dissent, and upon good debatement, deliberation, and conclusion determined, to put the same into a common leger, to remain of record for the company".*

Similarly, the compiler and cartographer Richard Hakluyt, seeking to identify commercial opportunities, specified the type of information to collect: locally grown plants, materials used to dye clothes. He advised bringing back samples[3]. Hakluyt understood that asking the right questions was not enough. It was also necessary to explain the context and motivations of the questions to the observer so that he understood what was at stake. Thus, Hakluyt took the trouble to explain that England produced the best fabrics and wools in the world, but that without dyeing, they were not appreciated by buyers in foreign markets.

[1] https://en.wikipedia.org/wiki/Intelligence_cycle
[2] Jan P. Herring, "Key intelligence topics: A process to identify and define intelligence needs", *Competitive Intelligence Review*, Volume 10, Issue 2, Q2, 1999.
[3] Daniel Carey, "Hakluyt's instructions: The Principal Navigations and sixteenth-century travel advice", in *Studies in Travel Writing*, Routledge, 2009, p. 14.

Purchase of foreign books

In 1584, the Dutchman Lucas Janszoon Waghenaer published the first nautical atlas *De Spieghel der Zeevaerdt (*The Mariners' Mirror). Sailors had always sailed using a series of tools such as maps, coastal drawings, written and oral instructions, depth soundings, landmarks, safe anchorages, and charts to find the altitude of the sun. For the first time, Waghenaer had put all this together in a single volume. He even gave the depths of the channels at low tide[1]. This book became the most important publication in the history of navigation. Its success was immediate. One year after its publication, Lord Howard (1536-1624), Lord Grand Admiral of England had it translated, corrected, and improved.

Scurvy was a great danger of navigation. Many sailors died of it, ships sometimes even losing 90% of their crew. In 1579, the monk and physician Agustin Farfán published a book in which he recommended oranges and lemons against scurvy, a remedy which was already known in the Spanish Navy. In 1593 Admiral Richard Hawkins applied these methods, which were later generalized[2]. The demand for lemons for curing scurvy became so great that Sicily got covered with lemon trees for supplying the English navy. The Sicilian mafia emerged in the 19th century for protecting the precious orchards from thieves[3].

The scholar John Dee collected all books related to the mining and metallurgical industry in Germany, Bohemia, and Hungary[4] . He acquired *De re metallica* written by the "father" of mineralogy, Georgius Agricola (1494-1555), and *De La pyrotechnie* written by the Italian arms manufacturer Vannoccio Biringuccio (1480-1539). These works contained a lot of practical information on promising mining sites, analysis and processing of ores, shaft drilling, and tunneling.

Buying information from brokers

Abraham Ortelius was a shrewd entrepreneur. He started as an apprentice by decorating and illustrating maps, including those of Gerard Mercator. He then went into trading. He bought maps, had them painted and embellished by his sisters and sold them in fairs all over Europe[5]. His clients included the great English cartographer Richard Hakluyt and the scholar John Dee. He was constantly exchanging letters with them, answering their questions and keeping them updated on his new acquisitions. In 1573 he

[1] Robert Baldwin, *"The development and interchange of navigational information and technology between the maritime communities of Iberia, North-Western Europe and Asia, 1500-1620"*, Masters thesis, Durham University, 1980. p. 250.
[2] https://en.wikipedia.org/wiki/Scurvy#History
[3] Arcangelo Dimico, Alessia Isopi & Ola Olsson, "Origins of the Sicilian Mafia: The Market for Lemons", *Working Papers in Economics N° 532,* School of Business, Economics and Law, University of Gothenburg. 2012.
[4] Robert Baldwin, "John Dee's interest in the application of nautical science, mathematics and law to English naval affairs", in Stephen Clucas, *John Dee: Interdisciplinary Studies in English Renaissance Thought*, Springer 2006, p. 115.
[5] Daniel Boorstin, *The Discoverers,* Random House, 1985, p. 295.

was appointed Royal Geographer to Philip II of Spain, but he continued exchanging cartographic information with the English.

Business trips abroad

During a visit to Italy, the English naval architect Matthew Baker discovered Venetian boat building techniques based on geometrical proportions. This inspired him in developing his *whole-moulding* technique, which guaranteed excellent nautical qualities to ships and made it possible to standardize the manufacturing process[1].

Informational Reports [2]

In 1620, the English ambassador to Germany, Henry Wotton, witnessed an original demonstration of the *Camera Obscura[3]* by astronomer Johannes Kepler. The basic principle had been known for a long time, but Kepler had found a clever way to use it for making topographical surveys and observing sunspots. Henry Wotton immediately wrote a detailed report to the scientist Francis Bacon[4].

Debriefings

The scholar John Dee advised several trading companies including the *Muscovy Company* and the *Cathay Company*. He trained their navigators and provided them with charts and instruments. He probably helped Francis Drake prepare his voyage around the world[5]. He debriefed navigators and pilots carefully upon their return. He was particularly interested in compiling information on islands that could serve as bases and intermediate stations for ocean crossing and places favorable for the establishment of colonies[6].

Trainings abroad

In the late 1540s, after completing his studies at Cambridge, young John Dee went to study in Leuven. He met some of the greatest cartographers of his time, many of whom became his friends, such as Gerardus Mercator[7] - who gave him maps and globes - and

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[1] Richard Barker, "Design in the Dockyards, about 1600" in *Carvel Construction Technique: Fifth International Symposium on Boat and Ship Archaeology* (Amsterdam, 1988), Oxbow Books, 1991, p. 64.
[2] https://fr.wikipedia.org/wiki/Rapport_d%27%C3%A9tonnement
[3] https://en.wikipedia.org/wiki/Camera_obscura
[4] Todd Andrew Borlik, "The Whale Under The Microscope: Technology And Objectivity In Two Renaissance Utopias", in *Philosophies of Technology: Francis Bacon and his Contemporaries*, Brill Academic Publishers, 2008.
[5] Eric H. Ash, *op. cit.*
[6] Paul J. McKittrick, *op.cit.* pp. 25, 35, 226.
[7] Adam Max Cohen. *"Tudor Technology in Transition"*. Dans "A Companion to Tudor Literature". Ed. Kent Cartwright. 2010.

Gemma Frisius[1] - who gave him various astronomical instruments. He could access the cartographic knowledge of the Spaniards, since the Low Countries were part of Charles V's Holy Roman Empire.

In 1553, on the death of King Henry VIII, his daughter Mary Tudor became Queen of England. A Catholic, she married the son of the King of Spain, Prince Philip. Steven Borough, a disciple of the navigator Sebastian Cabot and a great explorer of the Moscow Company, took advantage of this Anglo-Spanish rapprochement to train at the *Casa de Contratación* in Seville. He exchanged his knowledge of Arctic navigation for Spanish cartographic secrets. Two years later, he returned with a precious document in his luggage: Martin Cortes' *Arte de Navegar* navigation manual[2], a gold mine of information. It described in detail the manufacture and use of the most advanced navigation instruments such as the astrolabe, the quadrant, the Jacob's staff (*cross-staff*)[3]. The book also described methodologies for making nautical charts. Translated by the cartographer Richard Eden, it became the reference document for English navigators for nearly a century. It is very likely that the English pirate Francis Drake, who caused so much harm to the Spaniards, was one of the first buyers[4]. Steven Borough also brought back organizational innovations from Spain, such as the idea of an administration and schools dedicated to navigation, with rigorous examinations. The manufacture of the new navigational instruments was entrusted to English craftsmen, bringing considerable savings compared to their acquisition on the black market from Iberian intermediaries.

Exchange and barter of information

The mutual respect between the English pirate Francis Drake and the French privateer Guillaume le Testu grew into friendship. The latter showed Drake his personal atlas folio of 56 maps made from his own travels on the Brazilian coasts. He revealed to him that there must be a passage between the Atlantic and Pacific Oceans, south of Patagonia[5]. Drake used this valuable information during his voyage around the world. Having crossed Cape Horn, he intercepted a Spanish galleon filled with an exceptional treasure: more than 26 tons of silver. The bounty was so massive that Drake replaced the ballast of his ships with silver ingots[6]!

Relational networks

The scientist John Dee maintained an important scientific relational network. He constantly wrote letters to scholars all over Europe - Paris, Cologne, Antwerp, Ferrara, Heidelberg, Orleans, Rome, Verona, etc. He was a friend of many of them, such as the cartographer Gerard Mercator, the Portuguese pilot Pedro Nunez, and the Danish

[1] Jennifer M. Rampling. *"John Dee and the sciences: early modern networks of knowledge"*. In journal "Studies in History and Philosophy of Science". Editions Elsevier 2012. p.19
[2] P. J. McKittrick, *op. cit.* p. 171.
[3] R. Baldwin, *"The development and interchange of navigational information...", op. cit*. p. 238.
[4] David Childs, *Tudor Sea Power: The Foundation of Greatness,* Seaforth Publishing, 2010, p. 144.
[5] https://fr.wikipedia.org/wiki/Guillaume_Le_Testu
[6] Hugh Bicheno, *Elisabeth's Sea Dogs: How England's Mariners Became the Scourge of the Seas,* Conway, 2012.

astronomer Tycho Brahe. It was a kind of informal college of navigation[1] that formed the nucleus of the future *Royal* Scientific Society [2].

King Frederick II gave an island and considerable funding to Tycho Brahe for building his Uraniborg[3] observatory. Tycho Brahe was able to make astronomical measurements in the order of an arcminute, with ten times greater accuracy than before. This was incredible precision, like observing a football at a distance of 800 meters. His data was compiled in tables called the *Rudolphine*[4] *Tables*, which were kept secret and were not published until 26 years after his death by his disciple Johannes Kepler. They included not only tables of data but also algorithms, allowing users to compute future positions of planets[5]. It is likely that John Dee could access Brahe's data decades before any other European scientist.

Purchase of foreign products

As a Catholic, Queen Mary Tudor made an alliance with Spain. As a consequence, English naval architects gained access to the methods of design and manufacture of Spanish warships. She commissioned the construction of three galleons to Spanish standards: the 550-ton *Philip & Mary (*1554), the 600-ton Mary *Rose (II) (*1556) and the 600-ton *Golden Lion (*1557). These ships were an important evolution in English naval technology. The next generation, like the ships of pirates like Drake, Frobisher and Hawkins, as well as the new *race-built galleons* of the *Navy,* was developed upon Spanish technological foundations[6].

Reverse engineering [7]

The method of cylindrical projection introduced by Mercator in 1569 flattened the earth into parallel meridians, giving sailors regular and measurable landmarks to follow straight routes across the oceans (rhumb lines). Mercator had kept his projection formulas secret. While sailing in the Azores in 1589, thanks to his experience as a sailor and to his mathematical skill, Edward Wright cracked Mercator's mathematical formulas. He corrected its errors and invented a more accurate cylindrical projection. Going beyond publishing new maps, Edward Wright also provided calculation methods for making customized maps[8] . Instead of being mere users of Mercator maps, the English became self-sufficient in nautical cartography.

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[1] Richard Deacon, *John Dee. Scientist, geographer, astrologer & secret agent to Elisabeth I,* Frederick Muller, 1968, pp. 37, 93
[2] P. J. McKittrick*, op. cit.,* p. 229.
[3] https://en.wikipedia.org/wiki/Uraniborg
[4] https://en.wikipedia.org/wiki/Rudolphine_Tables
[5] https://www.pablogarcia.org/hackers-of-the-renaissance
[6] Angus Konstam. *"Tudor Warships. Elisabeth I's Navy"*. Ed Osprey, 2008. p.5
[7] https://en.wikipedia.org/wiki/Reverse_engineering
[8] Mark Monmonier. *"The Wright Approach. Rhumb Lines and Map Wars: A Social History of the Mercator Projection"*. Chicago, Ill.: University of Chicago Press. 2004. pp.65-67

Recruitment of foreign experts

In 1553, the English succeeded in recruiting the Portuguese pilot Antonio Anes Pinteado, who fled Portugal because he was involved in a murder. Pinteado piloted the English on their first trip to Guinea. Worried about the loss of strategic knowledge, the King of Portugal offered Pinteado his pardon and a title of nobility if he agreed to return[1]. The Portuguese cartographer Diogo Homem fled to England for similar reasons.

In 1561, the pirate John Hawkins made a secret deal with an entrepreneur from the Canary Islands, Pedro de Ponte. The goal was to enter the triangular slave trade. John Hawkins took care of transportation while Pedro de Ponte provided food, warehouses ... and intelligence. He put at Hawkins' disposal his pilot and personal navigator, Juan Martinez, who knew very well the Caribbean seas and the clandestine ports of traffic such as Monte Cristo on the island of Santo Domingo[2] .

Simon Fernandes was a Portuguese pilot trained at the *Casa de Contratación* in Seville who turned to piracy by joining forces with the English pirate John Callis. Fernandes was captured in 1577 and sentenced to be hanged. He was rescued by the Elizabethan spymaster Francis Walsingham who wanted to break the Spanish commercial monopoly in America. He convinced Fernandes to become a Protestant and enter the service of the Queen of England. The Portuguese accepted and then piloted several British expeditions to the Americas and the Azores[3].

On the night of August 7-8, 1588, the English attacked the Spanish Armada with boats full of explosives and incendiary material, which they drifted towards enemy ships. This maneuver caused chaos in the Spanish fleet. The designer of these boats -called *fire-ships* or *hellburners*- was the Italian engineer Federigo Giambelli, recruited by Queen Elizabeth[4] . The innovation was a delayed firing system built by a Dutch watchmaker. To prevent the three hellburner boats from being sunk by Spanish cannons, Giambelli used thirty-six empty boats as decoys[5].

The *Privy Council* ministers promoted the development of mining and metallurgical industries, and they even invested their private funds. Thus William Cecil (Lord Burghley), Secretary of State to Elizabeth I, was a major investor in the Royal Mining Company[6]. German mining experts such as Daniel Höchstetter and Burchard Cranach were recruited to carry out the drainage of mines and the crushing of rocks by machines driven by water bellows. Cranach imported the wire sieve technology that was common in Germany but unknown in England[7]. In 1564, the German expert Christopher Schutz, built England's first blast furnace in Tintern with the help of twenty German-speaking

[1] R. Baldwin, *"The development and interchange of navigational information ...", op. cit,* p. 108.
[2] http://tenerifeprivatetours.com/from-plymouth-to-adeje-in-canary-islands/
[3] https://en.wikipedia.org/wiki/Simon_Fernandes
[4] https://en.wikipedia.org/wiki/Hellburners
[5] https://www.warhistoryonline.com/instant-articles/hellburners-weapons-destruction.html
[6] James W. Scott, "Technological and Economic Changes in the Metalliferous Mining and Smelting Industries of Tudor England", in *Albion: A Quarterly Journal Concerned with British Studies*, Vol. 4, No. 2 (Summer, 1972), pp. 94-110.
[7] Andrew Foot, "Burchard Cranach (c 1515-1578)", text of a conference of the Lerryn History Society, November 19, 2010 (http://lerrynhistory.co.uk/docs/LER-13/LER-13-1.pdf).

workers. Schutz was paid the considerable sum of 10,000 pounds sterling for his technology transfer[1]. For the technology of metallurgy applied to iron cannons, Henry VIII imported many French foundry experts[2].

Elicitation[3] *and interview techniques*

The navigator Sebastian Cabot trained his sailing students on how to extract maximum information from the natives[4] . His first piece of advice was not divulging that they were of Protestant faith and pretending to respect local customs. He urged English sailors not to treat the people they met with disdain; on the contrary, they should remain circumspect and be gentle. Cabot presented the meeting as an opportunity for mutual amazement, a wonderful way to know the dispositions of the local people. He suggested inviting a native onboard for extracting knowledge. If a woman, then she should be treated with respect. The person, after being well entertained, was put ashore and used as an agent for encouraging others to cooperate further. Cabot added that making the person drink wine or beer would allow the English to "discover the secrets of his heart". If natives appeared on the shore with gold or precious stones, Cabot recommended approaching them while playing a musical instrument to induce a desire for contact.

The English cartographer Richard Hakluyt (1552-1616) was appointed chaplain to Sir Edward Stafford, England's ambassador to France, with instructions to obtain information on Spanish and French voyages to America. Using his ecclesiastical function as a pretext, he approached many sources of information of great value, such as Don Antonio, the pretender to the throne of Portugal, and "five or six of his best captains and pilots". He even found a way to get inside the Royal Library of Saint Martin abbey in Paris, where he took notes on the voyages of the French privateer Jacques Cartier to the gulf of Saint Lawrence in Canada in 1534[5]. He also retrieved information about the Spanish colonies in the West Indies, including details about their ports, the size of their garrisons and their food stocks[6].

Recruitment of competitors' employees

The Venetian navigator Jean Cabot entered the service of the English in 1496. His son, Sebastian Cabot, made his first navigations for the English kings Henry VII and Henry VIII. Then in 1512, he passed to the service of Spain where he was Pilot Major for thirty-five years and had access to the most advanced navigation techniques and cartographic secrets[7]. In 1547, Queen Elizabeth's *Privy Council* recruited him in order to transfer

[1] https://en.wikipedia.org/wiki/Christopher_Schutz
[2] Carlo M. Cipolla, *Guns, Sails and Empires. Technological Innovation and the Early Phases of European Expansion. 1400-1700,* Minerva Press, 1865, pp. 39-43.
[3] https://en.wikipedia.org/wiki/Elicitation_technique
[4] Daniel Carey, *op. cit*. p. 7.
[5] John Cooper. *"The Queen's Agent: Francis Walsingham at the Court of Elisabeth I"*, Faber & Faber, 2011, p. 242.
[6] Alan Haynes, *Walsingham. Elisabethan spymaster & stateman, The* History Press, 2004, p. 43.
[7] R. Baldwin, *"The development and interchange of navigational information...", op. cit.,* pp. 108, 226.

Spain's celestial navigation techniques[1]. The first step in the knowledge transfer was a navigation voyage in 1550 with the aim of training a new generation of English pilots. Among them was Matthew Baker[2], the great naval architect who built the new generation of warships that defeated the Spanish Armada. For this voyage, Sebastian Cabot asked English craftsmen to manufacture copies of Spanish navigational instruments, which raised their skills in metal engraving. In 1553, Cabot organized and directed the *Muscovy Company,* whose purpose was to discover the Northeast[3] Passage to China, and whose result was a very profitable trade with Russia.

In 1540, King Henry VIII launched a program of systematic poaching of French pilots. Sixty of them emigrated to England, including Jean Rotz, who was appointed Royal Hydrographer[4]. He brought with him many navigational books, as well as confidential documents. At the death of Henry VIII, the salary of Jean Rotz was cut in half and he accepted King Henry II's proposal to return to France.

Admiral Gaspar de Coligny, leader of the French Protestants, hired the navigator, Jean Ribault, to explore the coast of Florida with the goal of establishing a Huguenot colony there. Ribault went into exile in England in 1563 and offered his information, knowledge, and services to Elizabeth I. Having changed his mind, the English put him in prison, but he managed to escape[5].

King Henry VIII and Queen Elizabeth I employed Venetian naval architects - in particular Augustino Levello - for at least forty years in the construction of war galleys[6]. They imported the Italian technique of mounting the cannons in the center of the ship, not on the stern and bow castles, thus lowering the center of gravity and improving stability[7]. This allowed English captains to develop new formidable naval artillery techniques known as *Broadside Tactics.*

Information theft

The Dutch merchant Jan Huyghen van Linschoten worked from 1583 to 1589 in Goa as secretary to the Portuguese archbishop. He gained access to highly sensitive commercial, nautical and cartographic information, especially maps that the Portuguese had kept secret for more than a century. He stole nautical surveys of the seas of India, such as currents, depths, islands and sandbanks, which were vital for safe navigation, as well as coastal data for orientation. He described the main ports of anchorage: Bengal, Cochin, Malacca, Macau, Sumatra, Java. He detailed the Portuguese ways of trade, their way of life and their relations with the natives. He identified the most productive islands in the production of spices. The publication of this information opened the passage to the East

[1] P. J. McKittrick, *op. cit.*, p. 151.
[2] Eric H. Ash, *op. cit.*
[3] https://en.wikipedia.org/wiki/Northeast_Passage
[4] R. Baldwin, *"The development and interchange of navigational information...", op. cit.,* p. 213.
[5] *Ibid.* p.219
[6] N.A.M. Rodger, *op.cit.* p.195
[7] https://en.wikipedia.org/wiki/Tudor_navy

Indies to Dutch, French and English trade. As a result, the Dutch and the British were able to break the monopoly of the Portuguese on trade with the East Indies[1].

The English were the beneficiaries of information theft, but were also the victims. In 1547, the French soldier and cartographer Nicolas de Nicolay stole the *Rutter of the North,* a book of maps and navigational tips on the Scottish seas[2]. This was a serious leak of information to the English, as it could lead to an invasion of the kingdom by its enemies.

Kidnapping of foreign experts

One of the favorite activities of the pirate Francis Drake was capturing Spanish or Portuguese pilots. If they cooperated, they were rewarded; if not, they were thrown into the sea. In 1579, Drake captured the Spanish ship *Santa Maria* in the Cape Verde Islands. In the booty, Drake recovered an astrolabe, several nautical charts and the pilot Nuño Da Silva. The latter advised Drake during the crossing of the South Atlantic Ocean and along the coasts of Brazil. Drake finally freed Da Silva on the Pacific coast of Mexico where the unfortunate man was interrogated and tortured by the Spaniards. Sometimes Francis Drake would attack a boat just to retrieve a pilot or maps. For example, he captured Chinese pilots who guided him across the Pacific Ocean to Manila[3]. Drake was able to navigate the Asian seas as easily as the Spanish and Portuguese. Without the information from these pilots, Drake would probably have attempted returning to England via the Northwest Passage[4], north of Canada, which was eagerly sought by the English, but impractical because it was constantly frozen.

The special case of John Dee, master of elicitation and interview techniques

John Dee (1527-1608) was a scholar but also an intelligence agent, working for Elizabeth I and her spymaster Francis Walsingham. He signed his letters to the Queen with the acronym "ōō7", which probably inspired the writer Ian Fleming for the James Bond character[5]. Like many people of his time, John Dee enjoyed symbols with hidden meanings. Thus, the characters "ōō" represented his eyes, reserved only for the Queen. The number "7" was a sacred number symbolizing totality, such as the seven days of Creation or the seven colors of the rainbow. It meant that John Dee said everything to the queen, and to her only.

In 1583, John Dee left London for a six-year journey to Central Europe. This was the region with the greatest concentration of mines and metallurgical experts. It is

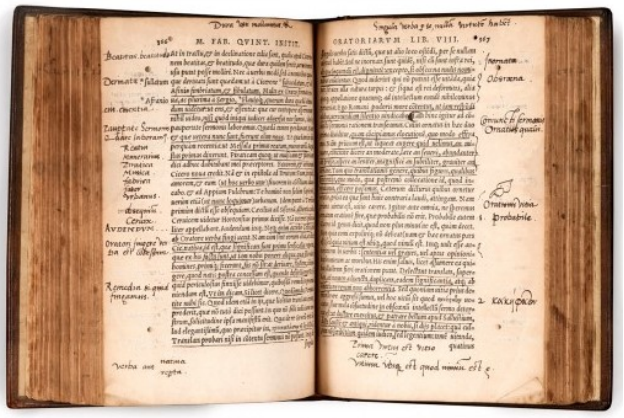
[1] https://en.wikipedia.org/wiki/Jan_Huyghen_van_Linschoten
[2] R. Baldwin, *"The development and interchange of navigational information...", op. cit.,* p.246
[3] https://en.wikipedia.org/wiki/Francis_Drake%27s_circumnavigation
[4] https://en.wikipedia.org/wiki/Northwest_Passage
[5] R. Deacon, *op. cit*. pp. 1-4.

possible that John Dee was conducting a technological intelligence mission there at the request of the Queen's *Privy Council.*

Honeypot techniques[1]

In the world of intelligence or computer security, a technique called *honeypot* is used to put forward attractive information in order to attract targets of intelligence operations. There is no need to search for information: sources come to you spontaneously and in confidence. John Dee probably used several honeypot techniques in his intelligence approaches: by opening his scientific library and by using his reputation as an astrologer and as an alchemist.

John Dee's library was one of the largest in Elizabethan England. It far surpassed the libraries of the universities of Oxford and Cambridge and is said to have contained 4,000 volumes. It was not only a library, it was also a scientific conservatory with many measuring and navigational instruments, maps, and globes. It was also a laboratory and an R&D center where he practiced alchemy and all kinds of experiments. He almost went broke buying rare books from abroad, such as Johann Trithemius' treatise on steganography, the most advanced book on cryptology of the time[2]. It seems that John Dee even employed a copyist in Rome for reproducing precious manuscripts[3]. His library was a must for any foreign scientist visiting London. This is how he met Gerolamo Cardano, the inventor of the Probability Theory, one of the greatest scientists of his time.



Annotated medical textbook by John Dee[4] .
Royal College of Physicians

Elizabeth I had chosen John Dee as her personal astrologer and consulted him on choosing her coronation date. When a new star appeared in the constellation of Cassiopeia in 1572, it raised considerable anxiety. People feared that it might foretell a great misfortune. Elizabeth I consulted John Dee, who reassured her that it was a favorable omen of her royal ascension in economic, political, and religious terms[5]. In Elizabethan times, the boundary between science and magic was not as clear as it is today. For many

[1] https://en.wikipedia.org/wiki/Honeypot_(computing)
[2] R. Deacon, *op. cit.* p.70.
[3] *Oxford Dictionary of National Biography*, entry on John Dee.
[4] https://www.rcplondon.ac.uk/news/lost-library-john-dee
[5] Susan Ronald, *The Pirate Queen,* HarperCollins e-books. pp. 182-183.

people, there was no difference between predicting the future in the stars and influencing it[1]. John Dee became a famous astrologer. Wherever he traveled, important people, nobles and courtiers flocked to him to get their horoscopes calculated and interpreted. His diary contained many references to such appointments with *Very Important Persons*[2].

Finally, princes and men of power were irresistibly attracted by his reputation as an alchemist, probably hoping that he could manufacture gold for them. This gave him access to the European royal courts. The list goes on: Emperor Rudolph II, Stefan Batory - King of Poland and Grand Duke of Lithuania -, Charles V of Spain, Maximilian II of Hungary, etc. Even the Tsar of Russia offered him a fortune to become his adviser. John Dee refused, but his son Arthur Dee, also an alchemist, accepted[3].

John Dee performing an experiment in front of Queen Elizabeth I.
Painting by Henri Gillard Glindoni. Wellcome[4] Collection .

Psychological profiles

Intelligence agencies have always carried out psychological profiles of political, economic, religious or military decision-makers[5]. This was of course practiced during the Elizabethan era. For example, during the negotiations on the possible marriage of Elizabeth I to the French Duke of Anjou, the spymaster Francis Walsingham asked John Dee to make a horoscope of the potential husband[6]. John Dee expressed a negative opinion and the Queen followed his advice.

In 1552, he met Gerolamo Cardano, one of Renaissance's most seminal scientists. As a professor of medicine, Cardano was first in describing the clinical symptoms of typhus. But he was also an avid player of cards, dices, and chess. His passion for gambling led him to invent the mathematical Probability Theory ... as well as psychological theories that he summarized in several books, including *De Genitura,* where he drew up

[1] Jason Louv, *John Dee and the Empire of Angels: Enochian Magick and the Occult Roots of the Modern World"*, Inner Traditions/Bear & Company, Kindle Edition, p. 87.
[2] R. Deacon, *op. cit,* p. 42.
[3] https://en.wikipedia.org/wiki/Arthur_Dee
[4] https://commons.wikimedia.org/wiki/File:Henry_Gillard_Glindoni_-_John_Dee_performing_an_experiment_before_Queen_Elizabeth_I.jpg
[5] "Jerrold Post : The man who analyzed the minds of world leaders", *BBC News*, 6 décembre 2020.
[6] Benjamin Woolley, *The Queen's Conjurer. The science and magic of John Dee, adviser to Queen Elisabeth I,* Henry Holt, 2001, p. 144.

astrological profiles of famous people[1], and his *Treatise on Dreams.* These books influenced Sigmund Freud, who considered him a true pioneer[2]. In 1558, Gerolamo Cardano published an astonishing work on *metoposcopy,* that is, the analysis of personalities and characters[3]. It was very detailed book, with more than 800 illustrations and commentaries. He analyzed facial features and looked for geometrical shapes matching astrological symbols.

Illustrations from Metoposcopia libris tredecim by Gerolamo Cardano [4]

Dee and Cardano collaborated on scientific[5] research projects. John Dee owned many books on metoposcopy[6]. During his stay in Prague, he stayed with a friend astrologer, Tadeus Hagecius of Hajek, who had also published on the subject. It is likely that John Dee used metoposcopy for profiling his intelligence targets before interviewing them.

Interview techniques

John Dee was famous for his scrying sessions, where he had conversations with angels. Entire books have been devoted to this subject. Less well known is the fact that important people came to him for answers to their questions from heavenly spirits. Historian Richard Deacon's theory is that John Dee used these sessions for extracting information from his visitors[7]: *"One has only to compare the narratives of the angelic conversations when Dee and Kelley were scrying alone with those when they were scrying with others to note certain subtle differences. When Dee and Kelley scried alone, the spiritual conferences were in the main didactic and almost entirely aimed at obtaining philosophical information ... But when Laski, Stephen or Rosenberg were involved, the proceedings were quite different. There was some spiritual probing after the secrets of the universe -probably*

[1] https://archaeologyofreading.org/bibliography/dee-corpus/cardano/
[2] https://fr.wikipedia.org/wiki/J%C3%A9r%C3%B4me_Cardan#Le_trait%C3%A9_des_songes
[3] https://en.wikipedia.org/wiki/Metoposcopy
[4] https://commons.wikimedia.org/wiki/File:Illustration_from_Cardanus,_Metoposcopia_libris_tredecim..._Wellcome_L0017244.jpg
[5] https://en.wikipedia.org/wiki/John_Dee#Later_life
[6] Martin Porter, *Windows of the soul. The art of physiognomy in European culture 1470-1780,* Oxford Historical Monographs, 2005, pp. 36, 116, 181.
[7] R. Deacon, *op. cit*. at 220.

enough to make it seem that this was Dee's main purpose- but the questions and answers between scryer and angels formed quite a different pattern, that of probing for information on purely secular matters".

It was through his mastery of interview techniques that John Dee was able to uncover one of the secrets most fiercely guarded by the Portuguese: the existence of St. Helena island. Isolated in the middle of the South Atlantic Ocean, it was an ideal supply base on the road to India. Portuguese ships could stock up on water and food discreetly because it was uninhabited. St. Helena was covered with forests and thus provided wood for repairs. John Dee heard about it on one of his trips to Rome and managed to locate it by collecting and analyzing bits and pieces of information[1]. Later on, the English of the British East India Company grabbed possession of the island. It is there that emperor Napoleon 1st went into his last exile.

Disinformation

The information provided to Sir Francis Walsingham by his European espionage network convinced him that a Spanish armada would be launched against England in 1588. He asked John Dee to calculate the weather and astrological conditions of an invasion. Dee replied that a devastating storm would cause a disaster in Europe. When the news spread and reached Spain, recruitment for the fleet slowed down and there were even desertions of sailors. In Lisbon, an astrologer who repeated the prediction was accused of spreading false information. Using psychological warfare, John Dee informed Emperor Rudolph of Bohemia and King Stephen of Poland that the predicted storm would "*cause the fall of a mighty empire".* Rudolf then transmitted the warning to the Spanish ambassador[2].

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Thanks to the technological catching-up of the period of the Tudor kings, the English navy became one of the most powerful in the world for almost three centuries. In 1588, it defeated the powerful Spanish Armada. In 1667, it was the Venetians who built their warships by copying English ship designs[3]. The metallurgical industry developed vigorously. The English manufactured cast-iron cannons for only 10 to 20% of the price of bronze ones[4]. They were recognized as the best in the world and became a very profitable export product[5]. Thanks to these many technical advances, England became the largest colonial empire in the world and began its industrial and scientific revolution.

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[1] *Ibid*. at 67.
[2] https://wikispooks.com/wiki/Document:The_British_Occult_Secret_Service
[3] Louis Sicking, *"Naval warfare in Europe, c. 1330- c. 1680"*, in *European Warfare in Europe*, chapter 11. Cambridge University Press, 2012, p. 236.
[4] N.A.M. Rodger, *op. cit,* p. 214.
[5] P. J. McKittrick, *op. cit*. p. 157.

What lessons can we draw from this remarkable technological catching-up?

First, intelligence is not a substitute for innovation, but it brings considerable savings of time and money.

Second, it is a discipline rich in relatively unknown techniques. Some of them are immoral and illegal. However, it is important to be aware of them, in order to protect oneself from them.

Third, the key to intelligence for innovation is not only providing technical or scientific information, but also bringing about a change in mentalities. The superiority of English warships over the Spanish ones originated from new concepts. Spanish ships were designed as floating fortresses and troop transports, while English ships were designed as floating and fast artillery platforms with specialized technical marine personnel. *Intelligence* also means making decision-makers more intelligent by bringing them new interpretations of their competitive environment.

But that's not all. We also need to address the internal barriers to change within organizations. In 1660 the French minister Colbert was impressed by the quality of the English warships and the economical shipbuilding methods of the Dutch. He sent various spies to these two countries - including his own son - with a very long and detailed list of questions. They did an excellent job and brought back a lot of technical information. For example, they learned that the Dutch assembled their ships with wooden mortise and tenon joints that swelled under the action of water, while the French assembled theirs with iron nails that rusted. But when Colbert wanted to impose these techniques in France, he met strong resistance from the masters of the shipyards who insisted on shipbuilding in the traditional way, in spite of the regulations and standards that he imposed[1].

In conclusion, intelligence is an incredibly effective practice that saves a lot of time and money. It must first be taken into account by decision-makers, but they must also involve their collaborators in its execution.

Yves-Michel Marti

[1] Larrie D. Ferreiro, *Ships and Science. The Birth of Naval Architecture in the Scientific Revolution, 1600-1800,* MIT Press, 2007, p. 91.