## Legend

Blue dashed lines: Era boundaries

Red dotted arrows: Additional tech requirements (two different shades of red to make them less difficult to trace)

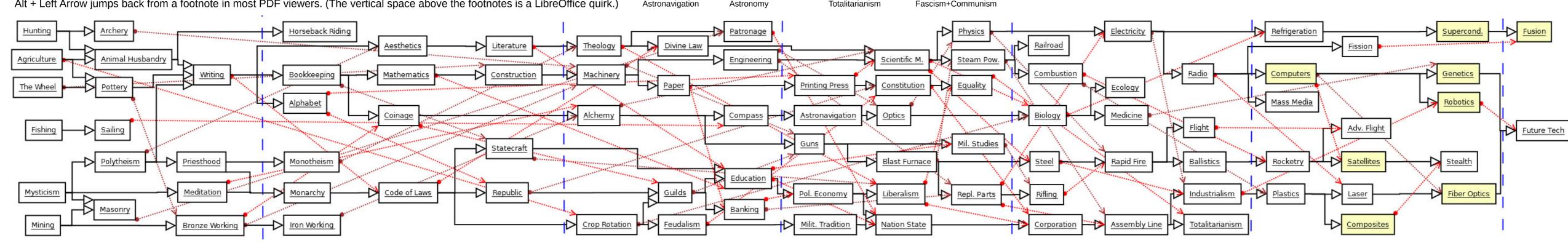
Yellow shade: Spaceship (SS) parts

Blue text: Different from BtS. Mere name or research cost changes not highlighted. When a tech name is blue, then almost everything about it is different from BtS.

Green text: Difference from BtS that is already implemented in AdvCiv.

Rationales in footnotes. These are mostly about historicity, whereas stat-changes.pdf mostly addresses game balance.

Alt + Left Arrow jumps back from a footnote in most PDF viewers. (The vertical space above the footnotes is a LibreOffice quirk.)



Correspondence between techs:

Calendar

Currency

Drama

Music

Civil Service

Philosophy

Metal Casting

Divine Right

Astronomy

Bookkeeping

Coinage

Statecraft

Republic

Alchemy

Crop Rotation

Divine Law

Patronage

- Hunting (60): Scout, Camp, Spearman (with Copper)
- Agriculture (60): Farm, Plantation (on Silk, Dye, Incense)
- Wheel (60): Road, Chariot (with Horse)
- Fishing (60): can work Coast, Work Boat, faster movement along rivers<sup>2</sup>
- Mysticism (60): Monument, Stonehenge, reveal Incense<sup>1</sup>
- Mining (60): Mine, can clear Forest and Jungle for no yield<sup>3</sup>
- Archery (60): Archer, Great Wall (req. 2 Walls)<sup>4</sup>
- Animal Husbandry (100): Pasture, reveal Horse and Silk,<sup>1</sup> Stable (with Horse or Ivory)<sup>5</sup>
- Pottery (90): Granary (with Agriculture)<sup>6</sup>, Cottage, Workshop on
- Sailing (120): Galley<sup>8</sup>, Lighthouse, trade along unowned Coast
- Polytheism (70): Moai Statues (with Sailing) Culture slider found Hinduism if discoverer owns a Buddhist city or if Buddhism not yet founded<sup>12</sup>
- Masonry (60): Quarry, Walls, Great Lighthouse (with Lighthouse), Pyramids<sup>13</sup>
- Writing (150): Library, Open Borders
- Priesthood (70): Temple, Temple of Artemis<sup>14</sup>, Oracle<sup>13</sup>
- Meditation (90):<sup>15</sup> Monastery<sup>16</sup>, found Buddhism if discoverer owns a Hindu city or if Hinduism not yet founded 12
- Bronze Working (120)<sup>17</sup>: Axeman (with Copper or Iron), reveal Copper, 20 yield from chopping Forest, Forced Labor<sup>18</sup>

- Horseback Riding (220): Horse Archer (with Archery, Horse)
- Bookkeeping (160):<sup>19</sup> Market, Gold trading,<sup>20</sup> Temple of Kukulcan (with Priesthood)<sup>21</sup>
- Alphabet (200): Spy, Commando promotion<sup>22</sup>, build Research, increases tech diffusion<sup>23</sup>
- Monotheism (150):<sup>24</sup> Organized Religion, Winery,<sup>25</sup> unless dicoverer owns a Holy City, found Zoroastrianism; if already founded, found Judaism instead<sup>26</sup>
- Monarchy (200): Hereditary Rule, Barracks, Fort<sup>27</sup>
- Iron Working (190): Swordsman (with Iron), Forge<sup>28</sup>, reveal Iron
- Aesthetics (280):<sup>29</sup> Mausoleum of Mausolos<sup>30</sup>, Statue of Zeus (req. 2 Monuments), Angkor Wat<sup>31</sup>
- Mathematics (240):<sup>32</sup> Aqueduct (with Mining)<sup>33</sup>, Hanging Gardens (with Aqueduct), centers the map<sup>34</sup>, Trireme (with Sailing, Bronze Working)35
- Coinage (320):<sup>36</sup> +1 rade route, build Wealth, Shwedagon Paya<sup>37</sup> (with Meditation)
- Code of Laws (270):<sup>38</sup> Courthouse, Caste System, Vassal agreement<sup>39</sup>
- Literature (350): Heroic Epic (with Library), 40 Great Library (with • Construction (400):<sup>42</sup> Catapult (with Archery<sup>43</sup>), Harbor<sup>44</sup> (with
- Lighthouse)<sup>45</sup>, Colossus<sup>46</sup> (with Forge), Bridge building Statecraft (400):<sup>47</sup> War Elephant<sup>48</sup> (with Horseback Riding, Ivory), Forbidden Palace<sup>49</sup> (with Courthouses), Guerilla promotion<sup>50</sup>, found Confucianism if discoverer owns a Taoist

city or if Taoism not yet founded<sup>51</sup>

• Republic (420):52 Parthenon (with Priesthood)53, Arena (with Masonry)<sup>54</sup>, Academy<sup>55</sup>, Triumphal Arch (with Construction)<sup>56</sup>

- Theology (800):<sup>57</sup> Apostolic Palace, Hagia Sophia, found Christianity if discoverer owns a Jewish or Zoroastrian city<sup>58</sup>
- Machinery (800):59 Watermill, Lumbermill, +50% chopping yield, 60 Crossbow (with Iron or Copper) 61
- Alchemy (700):<sup>62</sup> Pacifism, +10% research from Monastery,<sup>63</sup> found Taoism if discoverer owns a Confucian city or if Confucianism not yet founded<sup>64</sup>
- Crop Rotation (800):65 Serfdom66, can build Farm on Grassland without irrigation<sup>67</sup>
- Divine Law (1000):<sup>68</sup> Theocracy,<sup>69</sup> Spiral Minaret, found Islam if discoverer owns a Christian, Jewish or Zoroastrian city<sup>58</sup>
- Paper (1200):<sup>70</sup> University of Sankore, Bureaucracy (with
- Guilds (1300):<sup>72</sup> Pikeman (with Iron), Maceman (with Machinery, Iron), 73 Plantation (on Banana, Spice, Sugar) 74, Workshop on all flat tiles<sup>75</sup>
- Feudalism (800): Longbow (with Archery, Iron Working)<sup>76</sup> Knight<sup>77</sup> (with Machinery, Horseback Riding, Iron, Horse), Castle<sup>78</sup>, Vassalage civic
- Patronage (1400):<sup>79</sup> Sistine Chapel, build Culture, Cathedral, Stupa etc.
- Engineering (1500): Trebuchet, Windmill<sup>80</sup>, Notre Dame (with Theology), Taj Mahal (with Divine Law)81
- Compass (1400):82 Map trading83, Explorer, Grocer (with Guilds)84, Whaling Boats85
- Education (1500):86 University, Oxford University (with University)
- Banking (1500):<sup>87</sup> Bank, Great Merchant if first to discover<sup>88</sup>

 Printing Press (2000): +1 commerce from Village and Town, obs. Great Library<sup>89</sup>

BtS

Gunpowder

**Economics** 

Nationalism

Military Science

Democracy+Communism

Fascism+Communism

Chemistry

Artillery

Guns

Political Economy

Nation State

Ballistics

Rapid Fire

Equality

Blast Furnace

Military Studies

Totalitarianism

- Astronavigation (1900):<sup>90</sup> Caravel (with Construction)<sup>91</sup> Navigation II promotion<sup>92</sup>, +1 sight on water<sup>93</sup>
- Guns (2400):94 Musketman, Pinch promotion
- Political Economy (2100):<sup>95</sup> Mercantilism, +1 production from Lumbermill<sup>96</sup>, Customs House<sup>97</sup> (with Harbor), Versailles<sup>98</sup>
- Military Tradition (2400):<sup>99</sup> Cuirassier (with Guns, Horseback Riding, Horse), Kremlin<sup>100</sup>, Militarism<sup>101</sup>, Defensive Pact
- Scientific Method (2500):102 Tech trading103, +1 research per specialist<sup>104</sup>, obs. Statue of Zeus, Angkor Wat<sup>105</sup> and Monastery
- Constitution (2700):<sup>106</sup> Jail, Federation (with Nation State)<sup>107</sup> Representation, obs. Monument, Stonehenge<sup>108</sup> and Mausoleum of Mausolos<sup>109</sup>
- Optics (2500):<sup>110</sup> Galleon, Privateer (with Guns and Copper or Iron)<sup>111</sup>, trade across Ocean, Lookout promotion for naval units<sup>112</sup>, obs. Great Lighthouse<sup>113</sup>
- Blast Furnace (2700):<sup>114</sup> Cannon (with Iron)<sup>115</sup>, Frigate (with Optics and Iron), Grenadier<sup>116</sup>, Barrage promotion<sup>117</sup>, obs. Colossus<sup>118</sup>
- Liberalism (2500): Free Market (with Nation State), 119 Free Religion, Statue of Liberty (with Harbor and must be in Emancipation and Free Religion)<sup>120</sup>, obs. Castle<sup>121</sup>, Oracle<sup>122</sup> and Temple of Artemis<sup>123</sup>
- Nation State (2600):<sup>124</sup> Hermitage, Globe Theater (with Theater)<sup>125</sup>, free Great Artist if first to discover<sup>126</sup>
- Physics (2700):<sup>127</sup> Observatory<sup>128</sup>, free Great Scientist if first to
- Steam Power (3400):<sup>129</sup> Levee<sup>130</sup>, Workers build improvements faster<sup>131</sup>, Ironclad (with Iron and Coal)<sup>132</sup>, reveal Coal, Farms spread Irrigation<sup>133</sup>
- Equality (3100):<sup>134</sup> Emancipation, Police Headquarters, Security Bureau,<sup>135</sup> obs. Deer<sup>136</sup>
- Military Studies (2900):<sup>137</sup> Ship of the Line (with Optics, Blast Furnace and Iron), Military Academy (with Barracks)<sup>138</sup>, +1 movement on Roads<sup>139</sup> and along rivers<sup>140</sup>, Blitz promotion<sup>14</sup>
- Replaceable Parts (3300):<sup>142</sup> Drydock<sup>143</sup>, +1 production from Windmill, Watermill and Workshop 144

- Railroad (3700):<sup>145</sup> Rail Track (with Coal or Oil), Public Transportation (with Oil)<sup>146</sup>, can trade Crab<sup>147</sup>, Mining Inc. Executive (with Corporation, University), obs. Walls<sup>148</sup>
- Combustion (4100):<sup>149</sup> reveal Oil<sup>150</sup>, Oil Well, Airship (with Physics)<sup>151</sup>, Std. Ethanol Executive (with Corporation, University)<sup>152</sup>, obs. Whale, Dye<sup>153</sup>
- Biology (4700):<sup>154</sup> +1 food from Farm, can build Farms without irrigation, Cereal Mills Executive (with Corporation, University)<sup>155</sup>, obs. Temple of Kukulcan<sup>156</sup>
- Steel (4200):<sup>157</sup> Bunker<sup>158</sup>, Steelworks (with Iron, Coal, Forge)<sup>159</sup>, Cristo Redentor (with Theology)<sup>160</sup>, constructAncient and Classical buildings faster<sup>161</sup>, Creative Constructions Executive<sup>162</sup> (with Corporation, University)
- Rifling (4000):163 Rifleman, Cavalry (with Military Tradition, Horseback Riding, Horse)
- Corporation (4200):<sup>164</sup> Wall Street (with Bank), +1 trade route, State Property (with Equality)<sup>165</sup>, can train Executives at Universities<sup>166</sup>, obs. Great Wall<sup>167</sup>
- Electricity (5000):<sup>168</sup> reveal Aluminum<sup>169</sup>, Broadway (with Theater), +1 commerce from Watermill<sup>170</sup>, Coal Plant (with Coal)<sup>171</sup>, Hydroplant (with Steel), Three Gorges Dam (with
- Ecology (5100): Environmentalism<sup>173</sup>, Treatment Plant<sup>174</sup> Preserve Forest, National Park, 175 obs. Ivory 176
- Medicine (4200): Hospital (with power), Red Cross (with Hospital), Fallout Shelter (with Steel, Manhattan Poject)<sup>17</sup> Medic III promotion<sup>178</sup>
- Rapid Fire (4800): Machine Gun, <sup>179</sup> Field Gun <sup>180</sup>, Interception I <sup>181</sup> and Ambush<sup>182</sup> promotions, Mount Rushmore<sup>183</sup>
- Assembly Line (5200):<sup>184</sup> Factory (with Coal, Oil or power)<sup>185</sup> Infantry (with Rapid Fire)<sup>186</sup>, Universal Suffrage (with Equality)<sup>187</sup>
- Radio (7800):<sup>188</sup> Attack Submarine (Oil or Uranium)<sup>189</sup>. Rock'n'roll (with Arena<sup>54</sup>, power), Eiffel Tower (with Forge), reveal Uranium<sup>190</sup>; Air Recon can reveal Submarines<sup>191</sup>
- Flight (7000):<sup>192</sup> Fighter (with Oil), Bomber (with Radio<sup>193</sup>, Oil and Aluminum<sup>194</sup>), Carrier (with Coal or Oil or Uranium), Paratrooper<sup>195</sup>
- Ballistics (5500):<sup>196</sup> Battleship (with Coal or Oil or Uranium), Destroyer (with Radio and Coal or Oil), 197 Tank (with Assembly Line, Railroad and Oil)198
- Industrialism (7200):<sup>199</sup> Industrial Park (with Factory, power), Marine (with Rapid Fire)<sup>200</sup>, Transport (with Coal or Oil)<sup>201</sup>, Pentagon<sup>202</sup>, Aluminum Co. Executive (with University)<sup>203</sup>
- Totalitarianism (5500):<sup>204</sup> Police State, Permanent Alliance, Intelligence Agency, free Great Spy if first to discover, 205 obs. Parthenon<sup>20</sup>

- Refrigeration (8000): Supermarket (with power), +1 food from Fishing Boats<sup>207</sup>, Sid's Sushi Executive (with Corporation, University)<sup>208</sup>
- Computers (8400):<sup>209</sup> 100% conversion rate from Processes<sup>210</sup>, SS Life Support (with Ecology)<sup>211</sup>
- Mass Media (9000): United Nations, Hollywood (with Broadcast Tower), Broadcast Tower (with power), Civ. Jewelers Executive (with Corporation, University)<sup>212</sup>, obs. Apostolic Palace
- Rocketry (8500):<sup>213</sup> SAM Infantry (with Radio<sup>214</sup>), Anti-Tank<sup>215</sup>, Guided Missile, Nuclear Submarine (with Radio and Uranium)<sup>189</sup>, Missile Cruiser (with Radio and Oil or Uranium)<sup>216</sup>
- Plastics (8500):<sup>217</sup> +1 trade route from Harbor<sup>218</sup>, +3 happiness in all cities<sup>219</sup>, Offshore Platform<sup>220</sup>, obs. Fur, Silk<sup>221</sup>
- Fission (9500):222 Manhattan Project (with Nuclear Plant), Tactical Nuke (with Rocketry, Uranium and Manhattan Project), ICBM (with Satellites<sup>223</sup>, Uranium and Manhattan Project), **Nuclear Plant (with Uranium)**
- Advanced Flight (11000):<sup>224</sup> Gunship (with Oil); Jet Fighter (with Aluminum, Oil), Airport (with Radio, Oil)<sup>225</sup>, obs. Stable and
- SDI (with Manhattan Project)<sup>229</sup> Laser (11000):<sup>230</sup> Mobile SAM (with Rocketry, Oil), Howitzer<sup>231</sup>

Satellites (9000):<sup>227</sup> Apollo Project (with Plastics)<sup>228</sup>, reveal map,

- (with Ballistics and Oil), Space Elevator (with Satellites)<sup>232</sup>
- Composites (11000):<sup>233</sup> SS Casing, Mechanized Infantry (with Rapid Fire, Aluminum, Oil)<sup>234</sup>, Modern Armor (with Laser, Ballistics, Oil)<sup>235</sup>
- Superconductors (12000): SS Thrusters, Particle Accelerator (with Computers, Fission and power)<sup>236</sup>

Genetics (12000):<sup>237</sup> SS Stasis Chamber (with Refrigeration)<sup>238</sup>.

- +2 health, +1 food in Grassland tiles with at least 5 food<sup>239</sup> Robotics (10000): SS Docking Bay, +1 free Engineer from
- Industrial Park<sup>240</sup> Stealth (12000):<sup>241</sup> Stealth Bomber (with Advanced Flight,

Aluminum, Oil), Stealth Destroyer (with Oil or Uranium),

• Fiber Optics (12000):<sup>243</sup> SS Cockpit, Internet<sup>244</sup>

Air Recon can reveal stealth ships<sup>242</sup>

- Future Tech (10000):<sup>245</sup> + 1 health, +1 happiness
- Fusion (12000):<sup>246</sup> SS Engine, free Great Engineer<sup>247</sup> if first to discover

- 46 Adopted from Metal Casting, which is no longer a tech (see Coinage), 1 Dye seems to refer mostly to indigo, which was cultivated since 2500 BC. Considering that most Dye is blocked by Jungle initially, no additional tech should be required. Silk and frankincense are also preclassical trade commodities and come from simple tree plantations. For silk production, it's not enough to plant mulberry trees; the silkworms also need to be domesticated. Require Animal Husbandry for this. 47 Replacing Civil Service. Maceman (now at Guilds) and irrigation Without ritual uses, incense might not be valuable enough to plant incense trees, so Mysticism is required. To avoid introducing additional Plantation improvements, all early Plantations require Agriculture, and Mysticism and Animal Husbandry reveal Incense and Silk. About the other three Plantations, see Guilds. All six at the same tech (as in BtS) gives civs near the equator too many resources at once and allows too much city growth too early. The additional happiness in the early game is welcome since Slavery can no longer be used to work around unhappiness. None of the three
- resources are very powerful, and civs need to stretch a little to get them (remove Jungle or Forest, settle near Jungle or Desert). 2 As in Alpha Centauri, but only for Recon, Melee, Archery and Gunpowder units. Should make Fishing a bit more useful for civs that start with Fishing but not at a coast. 3 The BtS requirements for clearing Forest and Jungle suggest that metal
- tools. Some tech should be required for slash-and-burn because all other Worker jobs have tech requirements too. Mining somewhat fits because it may involve fire-setting, another fire-based technique. One could argue that equatorial rainforest is too dense and wet for slash-and-burn, but there is also no incentive to settle deep in the jungle in the early game, especially since Workers are going to have limited Similarly, clearing Forest without yield is usually a bad idea. For a chopping yield, Bronze Working is still required, as metal tools are

tools were necessary, but slash-and-burn doesn't require sophisticated

- indeed very helpful for making lumber. 4 Masonry is still required for the prerequisite Walls. Moving the Great Wall to Archery makes Masonry look less cluttered and gives players another reason to discover Archery. Barbarian activity increases gradually in AdvCiv, so an additional tech requirement shouldn't hurt
- Historically, one could argue that a large wall with flanking towers needs to be manned by archers to be fully effective. That said, other ranged weapons could also do the job, so this explanation is a bit
- 5 Earlier access to Stable should boost Chariot, but also allows Stables to 52 be constructed while researching Horseback Riding, so Horse Archer should benefit as well. 6 Pottery is reachable without Agriculture, but Granary needs to store grain, no other kind of food will do. The alternative requirement for Pottery has been changed from Fishing to the Wheel, and the Wheel is
- no longer a mandatory requirement. That is, the potter's wheel helps, but wheel-less civilizations are also allowed to develop Pottery. 7 Granting +2 production right away because +1 production, -1 food is very rarely worth building. The early Workshops should help convert excess food into production when cities reach the happiness cap. Forced Labor, the replacement for Slavery, also performs this conversion, but not nearly as effectively as Slavery.
- The terrain restriction should make Plains a bit more useful compared with Grassland. The early Workshops could represent brickyards, and Plains are clay-colored. 8 Should perhaps rename this to "Penteconter" to make clear how it
- differs from Trireme (triremes are also galleys, just a special type). 9 Polytheism (instead of Priesthood) as a requirement for Writing makes it easier to put Writing in the third column (where it belongs), and makes Polytheism more useful. In turn, Priesthood replaces Polytheism as the requirement for Monotheism. This way, the buildings unlocked by Theology and Divine Law (a.k.a. Divine Right) automatically
- require Priesthood. 10 Now a great wonder (see stat-changes-pdf). Replaces Temple of Artemis, which moves to Priesthood. The Moai depict deified (or at least venerated) ancestors, which is close enough to polytheism. As the wonder is (also) supposed to represent the colonization of small islands, Sailing has to be required in addition.
- 11 Adopted from Drama, which gets merged into Literature, as Polytheism may need another useful ability. Testing will have to show if the slider is indeed useful this early, or perhaps even too useful, in a way that discourages Temples.
- 12 This restriction ensures that Buddhism and Hinduism are founded close to each other. Along with other changes (see Monotheism), the coupling of these two religions should keep several civs without an early religion and thus make the later religions more useful. Could also give each of the two religions an increased chance of spreading in cities where the other religion is already present. (Same later for Taoism/ Confucianism 58
- and perhaps the Abrahamic religions too.) 13 Note that the abilities of the following wonders have (essentially) been swapped in a circle: Pyramids  $\rightarrow$  Parthenon  $\rightarrow$  Statue of Zeus  $\rightarrow$ Oracle  $\rightarrow$  Pyramids
- 14 Moved from Polytheism because Temple of Artemis shouldn't become available earlier than Temple. 15 Moved into the third column because the second column was too crowded. This means that Meditation can't lead to Priesthood. The new link to Monarchy seems justified by the (at times) Buddhist Maurya
- Empire, in which priests didn't have a major role. 16 The change to the ability of Organized Religion (see stat-changes.pdf) means that religions cannot be spread deliberately without Meditation, and this should make the tech valuable enough to be discovered
- eventually. If this takes a while all the better; then the Medieval religions have an easier time catching up with the earlier religions. 17 Kilns for smelting copper ores arguably (always) developed from pottery kilns, hence the Pottery requirement. Whether this is good for gameplay remains to be seen; it should make Mining a less powerful
- starting tech if nothing else. BtS requires Pottery for Metal Casting, which I'm replacing with Bronze Working and Coinage. 18 A.k.a. nerfed Slavery. Bronze Working isn't a plausible tech requirement for either civic, but I don't see a clearly better alternative. and the Ancient era should, when in doubt, remain as in BtS, so that the mod starts out in a familiar fashion. Or perhaps move it to the new Bookkeeping tech that replaces Calendar?
- 19 A new tech replacing/ encompassing Calendar. The problem with Calendar is that Plantations and the Mausoleum don't have anything to do with calendars, and, apart from other techs, I don't see anything else in the game that would require calendars. "Bookkeeping" is a very broad concept that could include commercial records, star catalogs and basic math, e.g. multiplication tables (leading to Mathematics).
- 20 Moved from Currency; see Coinage. 21 A.k.a. Chichen Itza. According to Wikipedia, "Kukulkan headed a pantheon [...] used to promote the Itza [...] commercial agenda." So Bookkeeping, as a (mainly) commercial tech, somewhat fits. Since it's a
- temple, Priesthood should be required. 22 Moved from Military Science (now Military Studies). I'm disabling this promotion for combat units (see "Commando" in stat-changes.pdf), along with the Spy unit.
- so it's not terribly relevant anymore and might as well become available 23 Tech trading with Alphabet would also be acceptable once tech trading is nerfed, but, ideally, tech exchange prior to Scientific Method (q.v.) should happen through automatic diffusion (and Spies for all I care). Historically, alphabetic writing may have accelerated tech diffusion

(though it was of course not a prerequisite).

were discovered around 1000 BC, and Judaism should be founded no earlier than that. My best bet regarding the Masonry requirement in BtS is that it should prevent one civ from founding all the early religions; not a problem anymore. Similarly, the link from Monotheism to Monarchy (one god, one king?) may have been an attempt to integrate the religious techs with the others, but it's too contrived, and not necessary either. The Ancient religious techs just need to provide *some* benefit to civs wanting to found the Medieval-era religions. Winery is such a benefit.

24 Now a Classical-era tech. The other techs in the first Classical column

- 25 Viticulture is far older, but that's covered by the 1 commerce granted by the bare Wine resource. Wine plays an important role in Judaism, and the Phoenician wine trade picked up around 1000 BC. 26 The Holy City restriction ensures that not all the early religions are founded by a single civ. Just as Buddhism and Hinduism are now coupled with each other (see Meditation), I'd like to make Judaism a prerequisite for founding Christianity and Islam (see Theology), but this is too narrow, so Zoroastrianism could be added to the game as an alternative requirement. Neither Judaism nor Zoroastrianism are
- proselytizing religions, so they should not be allowed to train 68 The divine right of kings was a Renaissance concept; not appropriate Missionaries (or no Monasteries). This will leave more room for Christianity and Islam, the most widely practised religions at present. Graphics for Zoroastrianism could be adopted from Realism Invictus, and it would be the favorite religion of the Persian AI leaders. 27 At the start of the game, Barracks are a waste of UI space and a trap for inexperienced players. Barracks pretty much imply a professional army, and these didn't really exist prior to the Neo-Assyrian Empire. The same goes for Forts as permanently garrisoned outposts.
- The Monarchy tech can't just represent (hereditary) kingship because that form of government is far older. It has to be something like the 69 Divine Law needs this more than Theology does, and a caliphate is very "Early Empire" civic in Civ 6, and that's just the right place for Barracks and Fort. These two also replace Winery, which moves to Monotheism. 70 Requires Machinery now (instead of Theology or Civil Service), 28 Moved from Metal Casting (see Coinage). A forge is normally operated
- by a blacksmith who works wrought iron (not east iron). 29 Polytheism as a requirement because all three wonders, except possibly the Mausoleum, should require Polytheism.
- 30 Previously at Calendar, which doesn't make any sense. The Mausoleum was most famed for the aesthetic value of its sculptures. The Mausoleum replaces the Parthenon, which moves to the new "Republic" tech.
- 31 Moved from Philosophy, which is now named "Alchemy". The actual construction date is in the 12th century AD; both Aesthetics and Philosophy appear much earlier in the game than that. This can't be helped. The wonder's ability is pretty narrow, so it's possible that no civ will want it before the High Middle Ages. Angor Wat takes the spot of Shwedagon Paya, for which it's easier to find an a new home (Coinage) than for Angkor Wat.
- It's important that the wonders unlocked by Aesthetics use different resources, so that the discoverer can likely benefit from at least one production discount. These three resources are Marble, Ivory and Gold in BtS, and now Marble, Ivory and Stone, which is also fine. 32 Mathematics has switched places with Calendar, which was then
- replaced by Bookkeeping. Bookkeeping could represent ancient (e.g. Babylonian) advances in arithmetics and geometry ("Math I"), and then Mathematics would be about Greek logics, algebra and trigonometry ("Math II"). The construction of long aqueducts required some math, including, arguably, algebra for the proper gradients. Moved elsewhere: Fort (Monarchy), increased chopping yield
- include some tunnels. Hence the Mining requirement. 34 Moved from Calendar. The size of the Earth was approximated through solar observation and trigonometry.

33 Aqueducts can also run underground, and bridge aqueducts often

- 35 Moved from Metal Casting, which came too late and has been removed (see Coinage); now assumed to be implied by Bronze Working. Triremes do require cast metal for the ram. It's not clear that the construction of triremes required advanced math, but it was apparently an intricate ship design. Wikipedia says that
- "propulsion, weight and waterline, center of gravity and stability, strength [...] are [variables] dependent on one another." 36 This is Currency rethemed as a metallurgic tech to replace Metal Casting as a bridge to the Medieval era. Metal casting (lost-wax casting) is very much a pre-Classical innovation. A civilization that 75 In BtS, Guilds gives Workshop +1 production, but now Workshop
- can make bronze also knows how to smelt and cast it. Bronze Working is required for the coinage metal: Early coins were usually made from silver, copper or bronze, and the refinement of silver 76 ores (cupellation) requires similar temperatures as the smelting of copper ores and bronze. (Whereas parting gold from silver requires metallurgic knowledge of salt cementation.)
- The English longbow came in use around AD 1000, so Longbowman can't be the first Medieval defender. That role is given to Crossbowman Some of the abilities of Currency (Wealth process, Market) have moved to Bookkeeping (the Calendar replacement) to give that tech something 77 Moved from Guilds (the other requirements are as in BtS; Machinery for manufacturing the armor). Guilds is now for units raised in cities,
- to do. The extra trade route should still make Coinage an important
- 37 Moved from Aesthetics. The spot there was needed for Angkor Wat. The real Shwedagon Pagoda was built no earlier than AD 500, but there 78 Moved from Engineering. A late Medieval tech requirement gives is no plausible tech requirement to enforce this, and the ability wouldn't work on a Medieval wonder.
- The donated gold (and diamonds) are what make the building special, and Coinage also has to do with gold. The Mon people that built the pagoda also had coins.
- 38 Requires Currency or Priesthood in BtS, which isn't unreasonable, but the authority of a great king (Monarchy) to enforce his law in a large domain seems more crucial to me. This change also integrates
- Monarchy better into the tech tree; it only leads to Feudalism in BtS. 39 I need room at Feudalism, and Code of Laws needs a replacement for Confucianism (now at Statecraft, a. k. a. Civil Service) and Chichen Itza (now "Temple of Kukulcan" at Bookkeeping). Client states have
- existed since the early Mesopotamian empires. 40 That's really National Epic, renamed. The BtS Heroic Epic becomes Triumphal Arch (see Republic).
- 41 Adopted from Drama, which gets replaced by Republic (q.v.). Drama is a form of literature. The culture slider (also at Drama in BtS) gets unlocked by Polytheism now.
- Masonry requirement. War Elephant moves to Statecraft.
- 42 Colosseum moves to Republic under the name "Arena" along with the 43 Catapults were typically torsion-powered, but developed from primitive 80 (tension-powered) crossbows.
- moves to Statecraft. The connection between compasses and harbors is a loose one at best. Creating a harbor (or enlarging a natural harbor) through a breakwater or dredging is a construction challenge. Changes to Harbor (flat trade route yield bonus, Merchant slot; see stat-changes.pdf) should make it a somewhat useful building by the time Construction is discovered.
- 44 Moved from Compass and taking the spot of War Elephant, which

45 Sailing needs to be required in some way, and a large (artificial) harbor

should be accompanied by a lighthouse.

- Castle have moved to earlier techs (Guilds, Feudalism). 81 Moved from Nationalism (now Nation State) because that tech Military Studies).
- requirement made no sense and to replace stuff that was moved away from Engineering, in particular the road movement ability (now at

Taj Mahal; the real mausoleum was built in the 17<sup>th</sup> century. Plus,

Divine Law (a. k. a. Divine Right) is required mostly in order to delay

representing an "Eastern way", and the latter a "Western way". Both are after I've switched Optics and Astronomy, but also in BtS). Historically, earlier Whaling Boats can be justified through Basque whaling in the 12<sup>th</sup> century. They did not use compasses, but Compass is the only naval Bookkeeping is required because good governance wouldn't be possible tech at the proper time. without extensive records. Because of its relation to the Chinese impe-86 Paper became widespread in Europe perhaps around AD 1200; the University of Oxford was established around AD 1100. So the Paper requirement in BtS doesn't work. The early European universities emerged from scholastic guilds, so this is the main path, and Statecraft

Divine Law can use a buff. Shah Jahan, who comissioned the Taj

84 Moved from Guilds, which didn't have enough room and comes a bit

85 Optics is too late for gameplay reasons: Whale has to go obsolete with

Combustion, and Combustion is quite close to Optics (even more so

too early (grocers started appearing in the 14th century). Kind of

replacing Harbor, which has moved to Construction.

Iron Working). Lodestones were of interest to alchemists.

(and so does Cristo Redentor; see Steel).

Paper (which now has Bureaucracy).

Mahal, was a Muslim. To be consistent, Notre Dame requires Theology

taking the place of Colosseum, which moves to Republic. Some of the

plates on the Colossus of Rhodes were of cast metal; this is sufficiently

covered by the Forge requirement. A 15 m high statue is a great con-

spread (now at Crop Rotation) don't fit well at Civil Service, and it's

governance, particularly meritocracy, as well as Chinese military

requirement. That's Paper, and Statecraft is required in addition.

hard to find Medieval replacements. The name "Statecraft" is supposed

to cover the philosophical basis of Chinese civil service, i.e. Confucian

strategy from the same period (Spring and Autumn). The civil service

system (imperial examinations) itself wasn't introduced until AD 600,

As a Classical-era tech, Statecraft accompanies Republic, the former

optional in the sense that they can be avoided until late Renaissance.

rial examinations, Statecraft is a shortcut to Education (avoiding the

development, but that's not really what Construction is about. War

49 The Forbidden City was built in AD 1420, but it may well take that

50 This is a new promotion, introduced for the Protective trait. Guerilla

51 Previously at Code of Laws, a better fit at Statecraft. While not

Elephant fits with the military aspect of Statecraft and elephants were

long until a civ has enough Courthouses. No tech is required in BtS.

primarily a religion, Confucianism competed with Buddhism and was

seen as incompatible with Christianity by the Catholic church, so the

representation as a religion has merit. Good relations among Confucian

rulers also make sense, and, while non-Confucians weren't regarded as

heathens, a small relations penalty doesn't seem inappropriate. (The AI

Hinduism (see Meditation). Two independent religions aren't needed at

this point of the game; perhaps Taoism should be removed entirely (see

leaders that favor Confucianism have only moderate religion-based

The connection with Taoism mirrors that between Buddhism and

Replacing Democracy (see Equality) and taking the spot of Drama,

because all outgoing arrows are optional (to Music and Philosophy,

other late Classical and early Medieval techs are a bit overloaded

The Republic tech also integrates Alphabet into the tech tree – the

to Statue of Zeus, still at Aesthetics. Parthenon gets the ability of

54 Although a Colosseum would fit very well under Republic, it's not a

Colosseum, with its arcades, would require Construction, but for a

55 The Republic tech allows Great Scientists to build Academies. Plato

56 This is a renamed Heroic Epic though with the 3D model of National

Requires Literature instead of Writing mostly because this allows

Theocracy moves to Divine Law, but Theology gets to replace

To capture the connection between the Abrahamic religions. The

connection with Zoroastrianism is thin, but Judaism alone would

probably be too restrictive. (Or perhaps Hellenism – at Aesthetics? –

would be the better choice for an 8th religion.) See Meditation, and

sawmills appeared during Late Roman times, but that was centuries

later than watermills, and the sawmills were not used for sustainable

Economics (now Political Economy). Replaceable Parts as in BtS is a

bit late, and Machinery too early. However, the chopping mechanism,

unrealistically fast deforestation if there is no Medieval Lumbermill.

The chopping yield bonus has moved from Mathematics (what does

chopping yield and Lumbermill become available at the same time.

61 See stat-changes.pdf about the Copper requirement. Archery should

a flintlock, and a bow is a primitive spring. However, Guns has two

other extra requirements (Machinery and Guilds), and two should be

is not a machine, and Crossbow doesn't have to require Archery

any Medieval tech. "Alchemy" is easier to integrate and closely

The Angkor Wat had to move in any case (now at Aesthetics).

64 Should perhaps be removed in favor of Zoroastrianism (see

Shi Huang) should be tolerant toward other state religions.

The two requirements, Coinage and Iron Working, are both about

metalurgy; Coinage could imply knowledge about gold extraction,

The research bonus should give both Monastery and Alchemy a power

Monotheism). Taoism didn't really spread outside of China. That said,

without Taoism, Pacifism would be difficult to justify at Alchemy, and

if Alchemy were removed, it would leave a hole in the Medieval era. So

long as Taoism is geographically tied to Confucianism, it shouldn't hurt

If Taoism stays in the game, then any AI leaders favoring Taoism (Qin

New tech that takes over Serfdom (from Feudalism) and the spread-

crowded and should really be a high Medieval tech (middle column).

Since Metal Casting has been removed (see Coinage), Crop Rotation

Crop rotation has been practised since prehistory, but this tech repre-

sents medieval crop rotation systems like the two-field, three-field,

European feudal system along with vassalage, but manorialism, an

early form of serfdom, emerged in the Late Roman Empire (which

67 This ability, together with a 1-tile irrigation spread from Aqueduct,

for the tech that founds Islam. (And the tech doesn't do anything

anyway.) So Versailles moves to Political Economy (formerly

through the scientific advances in the Islamic Golden Age.

of a writing material that was crucial for further developments.

by one civilization, so it's difficult to argue which tech should be

required from a historical point of view.

Economics) and the link to Nationalism (now Nation State) gets

connected to the Mandate of Heaven, which was an ancient concept

The name "Divine Law" refers to the Islamic belief that the Quran is

the literal word of Allah, and the sharia thus an immutable divine law.

The link to Scientific Method could be justified through the analytical

reasoning employed in Islamic jurisprudence (fiqh), or more generally

meaning that we're talking about paper mills. It's the cheap manufacture

Map trade has moved to Compass. It shouldn't really be much harder to

join maps gathered by different civilizations than to join those gathered

Civil Service has been replaced by Statecraft, a Classical-era tech, but

Bureaucracy should remain a Medieval-era civic, and Paper doesn't

have much else to do. This also preserves the relationship between

This requires both Machinery and Feudalism in BtS; now it's either

Republic (new tech, taking the spot of Drama). The Republic link

allows a direct transition from ancient poleis to medieval towns,

sidestepping Crop Rotation and Feudalism. The Currency (now

Statecraft) and Pikeman from Engineering. These were both rather

Guilds is an urban tech, so it gets units that were raised in cities.

came in use at about the same time as guilds (AD 900).

bizarre tech requirements; the original developers probably just saw no

better way to spread the Medieval units out. Knight is now enabled by

Pikeman is a pretty clear case; the pike was popular among mercenary

guilds. I'm treating Maceman as heavy infantry, which also tended to be

mercenaries, as peasants were not afforded costly armor. The mace also

For manufacturing their armor, Macemen require Machinery. Pikemen

tended to be less heavily armored, though I guess still heavily enough

to make bronze armor unaffordable (Iron required). All this is as in BtS.

The heavier Maceman should then of course also require Iron (not

74 About Plantations on Incense, Dye and Silk, see Agriculture. Bananas,

Copper as in BtS); instead Crossbow can be trained with Copper now.

spices (e.g. black pepper, cinnamon) and sugarcane had been cultivated

long before the Middle Ages, but the cultivated area grew dramatically

European citizens. Early cultivation is represented by the natural yield

As a high Medieval tech, Guilds comes a bit early for the East Indies

yields 2 production from the beginning (see Pottery). So, instead of

instead, and Longbowman becomes a larger, more flexible unit. Iron

Working is required for the arrowheads; see stat-changes.pdf for

Castle too little time to amortize before its obsoletion (Economics in

BtS, now Liberalism). Also, medieval castles had not advanced much

technologically from ancient fortifications; the novel thing about castles

was their role in the feudal system as the seats of power of feudal lords.

In order to make room for Castle and Knight, Serfdom moves to the

new Crop Rotation tech and Vassal agreement to Code of Laws.

79 Music renamed. A more specific name like "Art Music" could explain

why it's a Medieval tech, but still wouldn't match the abilities well. The

new name refers to arts patronage, which bloomed in the Late Middle

Ages. In many cases, e.g. the Sistine Chapel and many cathedrals, the

Roman Catholic Church was the patron, which is the reason for the

Theology requirement (and it helps integrate Theology into the tech

tree). The Culture process – turning commerce into culture (rather than

into gold) – is also a decent representation of arts patronage. The free

Great Artist moves to Nation State (formerly Nationalism), which now

Patronage requires Masonry because Masonry isn't required for

Construction anymore. I'm assuming Masonry to represent only

stonemasonry, and most buildings in the game could be built with

timber or bricks. But the large temples enabled by Patronage may

Moved from Machinery because windmills didn't become widespread

until the 13<sup>th</sup> century AD. (Although an earlier hill improvement to

represent terrace fields would be nice. Could perhaps allow the map

generator to place Corn or Rice on hills.) Conversely, Pikeman and

necessitate the grandeur and durability of stone blocks.

for both Plantation and Grocer, Grocer moves to Compass.

increasing the yield, Guilds only lifts the terrain restriction.

and Feudalism for units raised in the countryside: peasants

No need for Masonry: Japanese castles were timbered.

(Longbowman) and nobles (Knight).

requires Patronage.

trade. As a compromise, and because there isn't enough room at Guilds

during the Age of Discovery. Guilds were a part of the trade network

that established colonial plantations and delivered the produce to

bonuses of the three resources.

Coinage) requirement has moved up from Banking to Guilds.

73 Maceman has moved to Guilds from Civil Service (replaced by

Crop Rotation (which replaces Feudalism as an early Medieval tech) or

Paper and Civil Service (the former requires the latter in BtS).

replaces "Farms spread irrigation"; see stat-changes.pdf.

open-field or equal-field system (which justify the Code of Laws

66 Serfdom was introduced in the High Middle Ages as part of the

irrigation ability (from Civil Service). Feudalism was getting too

but Alchemy needs to do something.

which relates to the philosopher's stone.

the chances of Christianity and Islam much.

brings the tech count to 92, same as in BtS.

belongs to the Medieval era of Civ 4).

requirement) and possibly iron moldboard plows.

and education.

that have to do with lumber?) to Machinery, meaning that the maximal

be required for Guns (formerly Gunpowder) because there is a spring in

the limit. So Machinery gets the Archery requirement although a spring

Replacing Philosophy, which is a too generic name and couldn't lead to

connected to Taoism. Taoism, like all the major Chinese philosophies,

and pacifism too. Pacifism would fit better at Meditation or Statecraft,

had pacifist elements, so there is a remote connection between alchemy

forestry (whereas the Lumbermill improvement sustains the Forest

feature). The most appropriate place for Lumbermill would be

even if restricted to buildings and ships as I intend, leads to

Therefore, Lumbermill appears at Machinery, granting only 1

commerce, and Political Economy adds 1 production.

Monotheism about changes that should hamper the early spread of

a more useful ability (see stat-changes.pdf) than in BtS.

religions and thus give Christianity and Islam more room.

59 Bronze Working and Construction replace the Metal Casting

requirement (see Coinage).

Philosophy as the mandatory requirement for Liberalism (Western

medieval philosophy was largely theology), and the Hagia Sophia gets

founded his Academy in 387 BC, so Academies shouldn't appear in the

Epic (which shows a triumphal arch). Three powerful Marble wonders

at Literature are too many, and the name "Triumphal Arch" makes it fit

Theology to be placed next to Divine Law (formerly Divine Right) in

the tree and still have an incoming arrow. In BtS, Divine Right dangles

civ that isn't Rome, and out of time after the Classical era. The

generic arena, Masonry should be enough.

under Republic. See also stat-changes.pdf.

game long before that.

Pyramids instead, which fits very well at Republic. In BtS. Polytheism

which has merged into Literature. Drama is kind of a dead end in BtS

both a bit contrived). It's also a light tech with just three abilities, one of

which comes far too early (Globe Theater, now at Nation State), while

(Construction, Feudalism, Engineering) and would become even more

crowded after the removal of Metal Casting. Therefore a new tech, one

a certain literacy rate, and that alphabetic writing is easier to learn than

also Alchemy, the replacement for Philosophy).

for which it's easy to find abilities.

48 The saddle (howdah) may have been a significant mechanical

more costly Guilds and its prerequisites).

most exploited in South East Asia.

warfare was pioneered by Sun Tzu.

relations modifiers.)

so the corresponding civic, Bureaucracy, needs to have a Medieval tech

- (replacement for Civil Service) offers a shortcut, although Mathematics and Literature are required in any case as essential parts of the curriculum. Obviously, Education has to be a Medieval tech (not Renaissace as in BtS). 87 Instead of being required for Education (q.v.), Paper is now required for Banking. Banks antedate paper, and even once paper became used for receipts by the 14<sup>th</sup> century, the material was probably not crucial.
- printing press, and I don't see a better alternative. 88 The free Great Merchant switches places with Mercantilism because Banking has to be a Medieval tech, while mercantilism emerged in the 16<sup>th</sup> century. There are some famous bankers like the Medici and Fugger whom the Great Merchant could represent.

Nevertheless, some tech should illustrate the use of paper prior to the

- 89 Too many important buildings go obsolete at Scientific Method in BtS Obsoletion of the Great Library at Printing Press sounds at least as plausible as at Scientific Method.
- 90 Replacing Optics, which, in turn, replaces Astronomy. The name "Astronomy" has to go because Observatory plays better at Physics. "Astronavigation" does not imply an observatory, or at least not as strongly. The caravel was developed around AD 1450, whereas the telescope (→ Optics) was invented around AD 1600. The Jacob's staff came in use at around the same time as the caravel; the mariner's astrolabe followed around AD 1500. That said, none of these devices were crucial for Magellan's circumnavigation, nor for the discovery of America, so Astronavigation as the Caravel tech is a bit fantastical, but better than Optics.
- Whaling Boats have been moved to Compass as Optics and Astronavigation are too close to Combustion. An important innovation behind the caravel was its carvel planking;
- arrow to Currency in BtS is dubious. The idea is that a republic requires hence the Construction requirement. (Engineering would make Caravel 128 Moved from Astronomy, which was renamed to "Astronavigation" in too difficult to access for civs that start in isolation.) 92 This promotion has no tech requirement in BtS. I'm increasing the base 53 Aesthetics is a good fit for the Parthenon ability, which has now moved speed of Galley and Trireme by one, and Navigation I and II on top of
- that would make these ships implausibly fast. is the secondary requirement, but, as it's a temple, Priesthood should be 93 This might fit better at Optics, but I worry that it would take Caravels too long to discover other continents without the sight bonus. The normal sight range of ships is just 1. suitable name for a non-wonder building, and feels out of place for any New name for Gunpowder. The name "Guns" should make the link to

Blast Furnace (previously Chemistry) a bit more convincing, as in "the

- furnace is for making larger guns, " and it's a bit awkward to have the same name for a tech and a combat class (Gunpowder units). The Education requirement in BtS is dubious; Education helps innovation overall through University, but shouldn't lead to concrete inventions. Alchemy is a no-brainer. Guilds is additionally required because Musketman is getting a buff and mustn't be too easy to beeline to; gunsmiths were arguably organized in guilds. Machinery is also required because it's no longer implied by Guilds.
- 95 This tech comes too early for Free Market (The Wealth of Nations: 1776), and Mercantilism comes too early at Banking. Therefore push Free Market to Liberalism and turn Economics into the Mercantilism tech. Rename it to "Political Economy" because just "Economics" would be strongly associated with market economics, and in order to cover political philosophy as well. In mercantilism, economical policy followed political aims.
- This change moves Mercantilism and Free Market closer together, but these two civics need to be properly balanced anyway, so this shouldn't be a concern. (In BtS, Free Market is usually preferrable to Mercan-
- Castle still goes obsolete along with Free Market (i.e. at Liberalism). This extends the lifespan of Castle a bit further. The free Great Merchant moves to Banking to fill the gap left by Mercantilism.
- 96 To reduce deforestation, Lumbermill becomes available with Machinery, but yields only 1 commerce initially. The extra production at Political Economy gives Lumbermill the same yields that it gets in BtS at Replaceable Parts. The proper time for Lumbermill should be around 1500, when forestry became widespread in some parts of the 60 Lumbermill instead of Windmill (now at Engineering, q.v.). The earliest world. Political Economy is about right, and forestry also aligns with the mercantilist view of a state's land as a resource.
  - 97 Changes to Customs House and Mercantilism make the two compatible; see stat-changes.pdf. (In BtS, Customs House has no effect under Mercantilism unless the owner of Customs House has vassals.) 98 Moved from Divine Right (now Divine Law, q.v.). The Palace of Versailles was a symbol of absolutism, which is covered by the "Political" in Political Economy.
  - Nation State (new name for Nationalism) now requires Military Tradition and not vice versa. Military Tradition requires Feudalism because cuirassiers developed from knights and because the chivalric code also concerns military culture. Music has been renamed to Patronage and that requirement has moved down to Nation State. These changes make Military Tradition quite a bit faster to beeline to; however, Cuirassier still requires Guns (a. k. a. Gunpowder), whose

99 Cuirassiers and the military bands that the Music requirement hinted at

came earlier than nation states, not to mention nationalism. Therefore,

- tech requirements have become stricter. Cavalry still requires Military Tradition, but has visually relocated to Rifling, the much tougher of the two requirements 100 Moved from Communism (now called Equality), replacing West Point, which moves to Military Studies (new name for Military Science). The new Kremlin ability, faster Great General birth (see stat-changes. pdf), is unrelated to communism, and fits at Military Tradition. The Moscow Kremlin became a residence of tsars in the 16<sup>th</sup> century.
- 101 After a name change from "Nationhood" to "Militarism", Military Tradition is a natural match. That said, the Draft ability can't come this early; now requires adopting the Emancipation civic (at Equality) in addition to Militarism. See stat-changes.pdf. about this and the name
- boost, and acknowledge the role of Christian monasteries in scholarship 102 Now also represents early modern chemistry, whereas the Chemistry tech has become Blast Furnace. Early chemists like Boyle were among the pioneers of scientific method. Their writings were published in the middle of the 17<sup>th</sup> century, as were those of Descartes, Galilei and Bacon, so Scientific Method is very much a Renaissance tech, and should be contemporary with Astronomy (now Optics) instead of requiring that tech.
  - The new Alchemy tech (replacing Philosophy) is an obvious requirement, the others (Engineering, Printing Press) are as in BtS except that Divine Law (q.v.) can substitute for Engineering 103 The earliest example of a deliberate technology transfer between sovereign states that I'm aware of is the industrialization of Japan in the
  - 19<sup>th</sup> century. There is no science-flavored tech that late in the game though, and Scientific Method needs a strong ability (doesn't do anything valuable in BtS). Tech trading still has to be nerfed, regardless of Prior to Scientific Method, tech exchange should happen automatically through a tech diffusion system based on tile culture. See also Alphabet 104 K-Mod introduced this ability at Scientific Method, but eventually moved it to Computers. I think it is needed earlier because almost all
  - tile improvements get substantial yield bonuses in the Renaissance or Industrial era, while Great Person points from specialists decrease in value, and, after National Epic (now called Heroic Epic), bonuses to specialists come only from civics. On the other hand, the specialist bonus from Representation should be reduced by 1 research. Another measure to make specialists more attractive in the late game: higher initial yields in exchange for fewer Great Person points; see the Specialists section in stat-changes.pdf. 105 Since the three wonders obsoleted by Scientific Method in BtS (Great Library, Parthenon and Temple of Artemis) all get a discount from Marble, it's not rare that a civ loses more than one wonder with
  - Scientific Method, which is harsh. Now it's two wonders boosted by differing resources. Statue of Zeus gets the ability from Parthenon; so no change there really. (Parthenon gets the ability from Pyramids and goes obsolete with Totalitarianism, a. k. a. Fascism.) Angkor Wat goes obsolete with Computers in BtS, which is strange, and now that Angkor Wat becomes available earlier (Aesthetics instead of Philosophy), it's OK to let it go obsolete earlier. The obsoletion of Temple of Artemis moves to Liberalism, and the Great Library to Printing Press. 106 This tech has to refer to constitutions enshrining rights of parliamentarians and the rule of law; otherwise, Constitution would have to be a much earlier tech and wouldn't enable Jail. The earliest examples
  - appear to be Acts of the English parliament (Habeas Corpus, Bill of Rights) in the late 17<sup>th</sup> century. Constitution requires Nationalism in BtS, but it's hard to say if England was a nation state at that time. Requiring Nation State (new name for Nationalism) would also push Constitution into the third Renaissance column, which is mostly for discoveries at the onset of the Industrial Age (late 18th century). Nation State is instead an additional requirement for the Federation civic replacing Free Speech. The Feudalism requirement accounts for the roots of renaissance
  - constitutions in the Magna Carta (cited in the tech quote for Constitution) and, more generally, medieval constitutions determining the relations between king, nobility and clergy. The new rights for the (elected) parliament could be attributed to humanism (Republic required) and the increase in literacy brought about by the printing
  - 107 This civic replaces Free Speech, previously enabled by Liberalism. Since this should be a late civic, it only refers to post-feudal federations, the earliest example of which might be the Treaty of Union forming the UK. Early federations are covered by the Vassalage civic. 108 These go obsolete with Astronomy in BtS, but it's doubtful that Stonehenge had an important astronomical function. Hereditary Rule now gives Monument +1 happiness (instead of the military happiness ability), and losing that happiness is painful unless the obsoletion tech provides some remedy – such as the Representation civic. One could imagine that a constitution restricts the king's ability to erect monu-
  - 109 Most other ancient wonders go obsolete, so why not this one? Prolonged Golden Ages in the late game can also lead to a lot of military build-up, overcrowding the map. Could as well make e.g. Equality (replacement for Democracy) the obsoletion tech, but it's tidier to cluster obsoletions a bit. 110 Optics takes over the role of Astronomy; see Astronavigation. Engineering is required because all subsequent techs (Physics and Biology) should require it, and because Galleon should require it for its
  - architecture (naval engineering). All abilities of Optics really have to do 111 Early privateers (e.g. Francis Drake's Golden Hind) were galleons outfitted as warships. The Guns (a. k. a. Gunpowder) and metal requirements are for primitive cannons firing stone balls. Although the 3D animation shows cannon fire, Galleon is assumed to be lightly
  - armed with whatever ranged weapons are available (no Guns required). The move from Chemistry to an earlier tech should also give Privateer a longer window of opportunity. 112 See stat-changes.pdf about this. It's the Sentry promotion under a 113 Moved from Corporation for balance reasons: the two extra trade routes become too powerful with cross-ocean trade. Also, a lighthouse built for trade along the shores of the Mediterranean Sea shouldn't boost
  - trade across the oceans. In turn, the obsoletion of Colossus moves to Blast Furnace (a. k. a. Chemistry), and Monument and Stonehenge to Constitution. 114 New tech replacing Chemistry and, in a way, Metal Casting (see Coinage) – blast furnaces are used for smelting iron ore. Cannon needs to be at the same tech as Frigate, and that tech would be a poor representation of chemistry as a science. Instead, chemistry is now
  - represented through Alchemy (replacing Philosophy), Scientific Method, Steam Power (physical chemistry) and Combustion (petrochemistry). The production bonus to Workshop moves to Replaceable Parts (q.v.). 115 Moved from Steel. It's very strange to have such a long gap between Musketman and Cannon, when the two actually appeared in history at the same time. Guns (formerly Gunpowder) is still assumed to enable
  - an early cannon firing gunstones that is only used by Privateer (see Optics). The Frigate and Cannon units at Blast Furnace fire iron balls; hence the need for cast iron. Of course, this earlier Cannon, just one tech after Gunpowder/Guns, not requiring Engineering, needs to be smaller and weaker than the Steel
  - Cannon in BtS; see stat-changes.pdf. 116 Early grenades were made out of cast iron, so Blast Furnace is an excellent fit for this unit. This moves Grenadier one column to the left, while Rifleman moves two to the right (see Rifling), meaning that Grenadier is, as it should be, more often contemporary with Musketman than with Rifleman. The stats and abilities of Grenadier need to change
  - accordingly; see stat-changes.pdf. 117 Catapults and trebuchets aren't supposed to deal collateral damage anymore; see stat-changes.pdf. 118 Moved from Astronomy (now called Optics) to avoid making two naval wonders obsolete at once.
  - 119 Liberalism takes over Free Market from Political Economy (q.v.; formerly just Economics), but loses Free Speech (see Constitution) and the free tech. The free-tech ability isn't worth the distortions it causes in BtS (players always beelining to Liberalism and all techs near it). It also (probably) overstates the importance of liberalism for the increase of power and wealth in the West (i.e. the Great Divergence). There are still many powerful rewards for early discoverers of techs in the Renaissance era or one of the adjoining columns: tech trading; a free Great Merchant, Artist and Scientist; Guns, Rifling and Drafting.

- Nation State is an additional requirement for Free Market because market economics only emerged about a century later than liberalism as a political philosophy. The requirement should also illustrate the
- connection between liberalism and the national unification movements 82 Requires Alchemy now instead of Iron Working (but Alchemy requires in Europe during the 19<sup>th</sup> century. 120 Moved from Democracy, which has been replaced by Republic and 83 One can't claim that a compass is necessary in order to exchange maps, Equality (q.v.). These two techs are still indirectly required through the but the compass did improve the accuracy of maps (portolan charts) and Emancipation civic (now at Equality). Liberalism should be the main spurred naval exploration. And Compass needs the ability more than
  - requirement because it's the Statue of *Liberty*. The requirement to actually run liberal civics (rather than just knowing their prerequisite techs) is just for flavor. 121 The obsoletion of Castle has moved from Economics (now Political Economy) together with Free Market. It's not clear why an understanding of liberal economics (without adopting Free Market) should eliminate the economical benefits of castles, but at least it's a graceful obsoletion insofar as switching to Free Market makes up for
  - obsoletion tech. 122 See stat-changes.pdf about the new ability for Oracle, loosely based on the BtS ability of Statue of Zeus. This ability needs to go obsolete when Free Religion becomes available.

123 Moved from Scientific Method, where too many (Marble) wonders

route bonus from Castle to certain civics and choose a different

the lost trade routes from Castles. Alternatively, one could tie the trade

- went obsolete. Religious wonders might as well go obsolete with Liberalism instead of Scientific Method, and Temple of Artemis is even a mercantile wonder. 124 Nationalism arose in the 19<sup>th</sup> century; can't be a Renaissance tech. Even after renaming the tech to "Nation State" (and the Nationhood civic to "Militarism"), it has to be switched with Military Tradition, which takes over the Militarism civic, making Nation State entirely a cultural tech.
- The Dutch Republic around 1600 and the restored Kingdom of Portugal (1650) could be seen as early examples of nation states. Require Education because an education system needs to be required at some point on the path to a modern state. Patronage corresponds to Music in BtS, which was required for Military Tradition; that requirement has moved one column down the tech tree. It's needed for the nation's cultural identity. The Political Economy requirement (alternative to Military Tradition) alludes to theories that attribute the emergence of nation states more to economical developments than to
- 125 Moved from Drama, which got merged into Literature. Makes sense for a tech called "Nation State" to enable more than one national wonder. 126 Moved from the Medieval tech Music (now called Patronage) and replacing the Taj Mahal (moved to Engineering). The free Great Artist should really appear in Renaissance, and famous compatriots help shape a nation (e.g. national poets).

national sentiment.

- 127 Newton's laws, pivotal for modern physics and paraphrased in the tech quote (though that quote will have to move to the new Rapid Fire tech), were published in the 1680s, so Physics should be a Renaissance tech. Newtonian physics can't be lumped together with the discovery of Uranium (around 1900) though; this moves to Radio. Airship moves to Combustion (q.v.).
- belongs at Optics, but the first large observatory (Greenwich) did not open until 1676, and Physics needs this building much more than Optics does. This also moves Observatory farther away from University – cities don't need two buildings that boost research in a row. 129 The Watt steam engine went into production in 1776, but steam engine parts were not interchangeable until 1880. Therefore Steam Power

order to allow Observatory to move. The telescope (1608) very much

- shouldn't require Replaceable Parts. Scientific Method is required in addition to Blast Furnace (which replaces Chemistry) to account for prerequisites in early chemistry, e.g. gas laws and pneumatics. Blast furnaces are needed for the cast iron parts of the engine I'm drawing the line between Renaissance and Industrial era in the early 19th century; otherwise, there are too many techs for the Industrial and
- Modern era. I also don't want to push Railroad into the middle Industrial column. Let's look at the steam engine as a catalyst of the Industrial Age rather than a part of it. The Hagia Sophia gets a different ability and no longer goes obsolete (BtS: obsolete with Steam Power).
- 130 Levee at Steam Power (same as in BtS) makes sense to me because river transportation on steamboats increased the need for river engineering. 131 Same as in BtS. Makes some sense because steam engines were used in
- ly help constructing houses, roads or railroads though. Steel would fit better, but doesn't have room. 132 Moved from Steel to give Ironclad a longer window of utility. Also, the first ironclads, produced in 1862 for the US Civil War, were not clad in modern steel; the first steel mill in the US based on the Bessemer
- process was set up in 1865. 133 This ability represents the large American aqueducts that stretch across hundreds of miles. Steam Power is needed for the pumping stations. 134 Replacing Democracy. The name "Equality" allows the tech to become an additional requirement for the State Property civic (main require-

ment: Corporation, q.v.), and then the rest of Communism can be

1776) is, in my mind, the most important difference between the USA (or the First French Republic) and the European monarchies of the 18<sup>th</sup> century, many of which had practically abandoned serfdom, but had not renounced it. Similarly, suffrage existed e.g. in medieval England, but wasn't universal. Universal Suffrage moves to Assembly Line (q.v.), with Equality as an additional requirement. Assembly Line can explain the production bonus better. The Statue of Liberty moves to Liberalism (q.v.), though

Equality is indirectly required. Liberalism is, strangely, not required for

merged with Fascism into "Totalitarianism". Regarding Emancipation at

Equality, the notion that "all men are created equal" (Thomas Jefferson,

- Democracy in BtS, but was a major influence on the revolutions in France and America. 135 Scotland Yard, renamed as Police Headquarters, takes over the role of Security Bureau as a regular building, while Security Bureau becomes the special building that a Great Spy can construct; see statchanges.pdf about this. Police agencies were restructured in the early Industrial Age due to population growth in metropolitan areas and legal and philosophical changes regarding the role of police. There are several other techs where Police Headquarters would also make some sense (e.g. Railroad); Equality has room and partly replaces Communism, so, in a way, the building stays where it was. A similar case can be made for Security Bureau at Equality. The FBI and MI5 were only founded in the early 20<sup>th</sup> century, but that's OK: after discovering Equality, it may still take a civ quite some time to get a
- Great Spy for building a Security Bureau. 136 Part of an effort to make resources less crucial for city growth in the late game. In Europe, and perhaps elsewhere, game populations shrunk once hunting stopped being a privilege of the nobility. 137 "Military science" is the more commonly used term, but would suggest that Scientific Method is required. Scientific Method is directly required for four other techs, which should be the maximum, and military science is (mostly) not science in a strict sense. Requires
- Education for the "studies" part (and in turn Statecraft, the Sun Tzu tech), and Blast Furnace (previously Chemistry) only for Ship of the Line. The other unit that requires cast iron, Grenadier, has moved directly to Blast Furnace (q.v.). The Commando promotion has moved to Alphabet (q.v.). 138 This is West Point, moved from Military Tradition and renamed to something less US-centric (it gets pretty bad in the second half of the
- tech tree). The Military Academy special building gets removed for gameplay reasons (military production too fast in the late game). 139 Moved from Engineering. A rather major change that should extend the mobility advantage of ships over land units. It's also a big boost for Military Studies (even though Railroad in the next column somwhat obsoletes the road bonus). The bonus is supposed to represent advances in logistics (e.g. supply depots) and operational warfare.
- much later and get Blitz for free. To my knowledge, early modern ships didn't carry out any tactics resembling tank warfare; especially not ships of the line. So the name of the promotion is problematic, but the ability is fine (see "Blitz" in stat-changes.pdf). If ships got a Blitz promotion with a different name, then which tech would enable Blitz for Armored units?

141 Blitz is really only enabled for ships here because Armored units appear

- 142 Replaceable Parts can be dated no earlier than 1800, but I'm still leaving it in the Renaissance era (along with Steam Power) so that Rifling can be in the first Industrial-era column. Also, the first machine tools were developed in the late 18<sup>th</sup> century. About the Banking requirement (same as in BtS), one could argue that loans are required for large-scale manufacturing, which benefits most from interchangeable parts. Blast Furnace (replacing Chemistry) is required for cast iron parts. Engineering is required for Chemistry in BtS; this requirement moves one column down the tree to Replaceable Parts.
- 143 Moved from Steel in order to boost Ironclad and especially Ship of the Line, which has to cost more than Frigate, but isn't a lot more useful. Drydocks have antecedents in the Chinese Song dynasty and were widely used in England since about 1600. I see no direct relation between drydocks and replaceable parts, but the other techs in the same column would fit even worse or do too much.
- 144 The bonus to Workshop has moved from Chemistry (now called Blast Furnace) and replaces Lumbermill, which is now enabled by Machinery and boosted by Political Economy. Blast Furnace does other things, and it's neater to have all the improvement bonuses at one tech. 145 Doesn't require Steel because railroads were already widely used (e.g.
- the First Transcontinental Railroad in the US) prior to modern steelmaking. Machine Gun has moved to the new Rapid Fire tech (q.v.).
- 146 Moved from Combustion because Combustion no longer requires Railroad. The Oil requirement implies Combustion, so there is no real 147 Prior to Railroad only a local health bonus (or, easier to implement: none) because crabs are difficult to conserve (more so than fish). Transportation on rail made food from crustaceans available farther inland. Full availability should realistically require Refrigeration, but,
- that late in the game, +1 health might be insignificant. 148 Moved from Rifling. Firearms didn't make city walls completely obsolete, and the effect of firearms is already captured by the high bombard rate of Cannon (which I intend to increase further). The German Wikipedia cites a German author, Jürgen Osterhammel, stating that "if anything made walls obsolete, it was the railroad," and argues that city growth (urban sprawl?) caused walls to be abandoned. This line of reasoning makes it unnecessary to exempt the "defensive abilities" of Walls from obsoletion. Simpler is better, and that exception

is confusing because *all* abilities of Walls are defensive.

move to Ballistics and Industrialism. Just for the engine, Steel shouldn't be required, just as it isn't required for Steam Power. Railroads don't seem to have had a strong impact on the development of internal combustion engines. One could argue that it was mostly the availability of coal in England that let external combustion engines (steam engines) mature earlier than internal ones, and that Combustion shouldn't even require Steam Power. This would add another outgoing arrow to Scientific Method though, which is already required for four other techs. Public Transportation moves to Railroad, additionally requiring Oil,

149 Requires Railroad and, indirectly, Steel in BtS. Steel made sense for the

ships (Destroyer, Transport) enabled by Combustion in BtS, but these

- meaning that Combustion also remains required. 150 Moved from Scientific Method. There are no units that require Oil in the first two Industrial-era columns, so Combustion (in the first column) is early enough, and systematic oil exploration only began in the second half of the 19<sup>th</sup> century, not in Renaissance. 151 Moved from Physics. Airships are dirigible, and for that they require an
- internal combustion engine. Physics is still an additional requirement for Airship, representing aerostatics. Hydrogen production (late 18th century) is, I guess, implied by either Scientific Method or Combustion. Electricity should perhaps also be required because of the aluminium frame of zeppelins, but this might shorten the time during which Airship is useful for air attacks too much. 152 Moved from Plastics and taking the spot of Creative Constructions, which moves to Steel. Combustion is the most straightfoward
- requirement for a fuel company. (Standard Ethanol isn't primarily about biofuel anymore; more like Standard Oil. See stat-changes.pdf.) 153 Part of an effort to make resources less crucial for city growth in the late game; no obsoletion in BtS. The production of indigo nowadays often involves petrochemical cracking, but it seems that no petrochemistry was involved when the synthesis of indigo first became
- commercially viable around 1900. So the obsoletion doesn't quite fit at Combustion, but Industrialism would be a bit late and already has a lot 154 The Chemistry requirement is gone because Chemistry has been replaced by Blast Furnace, which doesn't work as a requirement for Biology. Early modern chemistry is instead represented by Scientific
- Crop Rotation is required because the food bonus to Farms should, among other agricultural innovations, represent four-field crop rotation (although this technique was not developed by biologists). National Park moves to Ecology (q.v.).
- just about any other foodstuffs I can think of. Grain corporations began to form in the 1850s, toward the end of the British Agricultural Revolution. Earlier access to Cereal Mills shouldn't be a game balance problem; the numbers just need to be tweaked accordingly. 156 This obsoletion only makes sense because of the new agricultural ability for the Temple of Kukulcan (called Chichen Itza in BtS). Cf.

155 Moved from Refrigeration – grains benefit from refrigeration less than

- stat-changes.pdf. 157 Cannon has moved to Blast Furnace (replacement for Chemistry), Ironclad to Steam Power and Drydock to Replaceable Parts. For all of these, Steel could be justified as a requirement, but they'll play better at earlier techs. Instead, the Steel tech focuses on uses of steel in construction, especially in beams and reinforced concrete.
- 158 Moved from Electricity. Bunkers are built in reinforced concrete. It's not clear if Bunker is supposed to represent bomb shelters (as the Civilopedia text suggests) or actual bunkers; I'm assuming that it's both, and that the Bomb Shelter building is really a fallout and blast shelter shouldn't require electrification.
- 201 Moved from Combustion. This change should help Ironclad and Ship of against nuclear attacks (see Medicine). Bunkers and air raid shelters 159 "Ironworks" sounds like it should be at Blast Furnace. For a modern steel mill, "steelworks" is the more common term (or at least more specific). See stat-changes.pdf about the resource requirements.

160 Moved from Radio; I'm not seeing the connection. The statue is built in

reinforced concrete. Steel is a bit early considering that the statue was finished in 1931; however, a similar statue on the same mountain had already been proposed in the 1850s. Theology is required in order to be consistent with Notre Dame requiring Theology (see Divine Law). 161 This ability should make it more worthwhile to found cities past the

midgame, especially on land discovered through Caravels. Improved

construction methods seem like the best historical explanation.

162 Moved from Combustion; Combustion gets Standard Ethanol instead. As the modern construction tech, Steel is the most natural place for Creative Constructions. 163 The Rifleman 3D model appears to show a soldier from the Napoleonic Wars, but the Civilopedia text talks about the American Civil War. The

latter makes more sense because rifles didn't supplant muskets until

about 1850 (Minié rifle). This interpretation also gives Musketman

- more time to shine. Consequently, Rifling becomes an Industrial-era The Military Studies (formerly Military Science) requirement should make it harder to beeline from Guns (formerly Gunpowder) to Rifling, and integrates Military Studies better into the tech tree. Historically, this additional requirement represents advances in logistics more than in tactics. (Though, admittedly, very large troop contingents were already fielded in the Napoleonic Wars, i.e. half a century before rifles became the default firearms.)
- 164 Requires Liberalism instead of Economics (now Political Economy) in order to integrate Liberalism better into the tech tree, and because Free Market has moved from Economics to Liberalism. (That said, it's not so clear that market economics are a prerequisite for limited liability and other aspects of modern corporations.) 65 Communism has (in part) been replaced by Equality, and Equality is still required for State Property. Either Corporation or Liberalism should be required in addition because the concept of social ownership developed in response to capitalism. Corporations were only beginning to spread in Marx's time, but the (new) abilities of the State Property
- civic (see stat-changes.pdf) are focused on corporations, so it doesn't make much sense to allow the civic before the Corporation tech. 166 That is, no HQ is required. This change lowers the initial investment for spreading a corporation, allowing corporation yields to be reduced substantially, which should improve the pace of the late game. See also

167 Because the new ability of the Great Wall grants an extra trade route,

and too many extra trade routes could encourage city spam. The

obsoletion of the Great Lighthouse moves to Optics.

equipment like light bulbs, resistors and switches. 169 Moved from Industrialism. Electricity fits better historically: The Hall-Héroult process (1886) for smelting aluminium ore involves electrical current. The discovery of this process made aluminium viable as a construction material. Now that Bomber requires Aluminium, Industrialism is also a bit late (same column as Flight).

168 Requires Replaceable Parts for mass-manufacturing electrical

requirement for Broadway. No commerce bonus to Windmill. 1 food, 1 commerce, 1 production (from Replaceable Parts) is good enough compared with Mine (2 production, 3 with Railroad). Wind turbines are better represented by the bonus from Environmentalism; didn't become widespread until the Oil Crisis. 171 Moved from Assembly Line. The Assembly Line requirement makes some sense in BtS because Assembly Line enables Factory, which, in

170 See stat-changes.pdf about the Watermill commerce and the Theater

are some buildings, e.g. Broadcast Tower and Hospital, that also require power, but don't require Assembly Line. Electricity should be required for all power plants in any case. 172 Both moved from Plastics because hydroplants were the earliest power plants, in use long before the discovery of synthetic polymers. Steel is required for the reinforced concrete. The power plants take the place of Bunker and Bomb Shelter (now called Fallout Shelter), which move to

Steel and Medicine.

with the post-WW2 environmental movement, but the Environmentalism civic is rarely useful that late in the game. For that reason, presumably, Environmentalism was moved to Medicine in patch 1.52. Better to keep it at Ecology and move Ecology into the Industrial era. Biology covers the technological prerequisites for ecology as a science. The motivation for this science (nuclear or plastic pollution in BtS) is captured by whatever health problems civs experience in the game; civs that don't need more health aren't going to research Ecology. mines and, to an extent, as traction engines on farms. They didn't exact- 174 New name for Recycling Center; see stat-changes.pdf.

173 Ecology is a Modern tech in BtS, requiring Fission or Plastics. This fits

- 175 Forest Preserve has moved from Scientific Method and National Park from Biology. These techs have enough other things to do, and Ecology is the most natural fit for ecological preservation. Perhaps the BtS developers felt that Ecology came too late, but that isn't an issue
- Ecology is still required for SS Life Support, but Computers (q.v.) is now the main requirement. The Scrub action has been removed; see Exclusion Zone (new name for the Fallout feature) in stat-176 Moved from Industrialism because that tech looked too crowded in BtS, and because synthetic substitutes have not diminished the monetary
- value of ivory that much. 7 Moved from Electricity and renamed from "Bomb Shelter" to "Fallout Shelter". A bomb shelter is also a protection against air raids, but the building only protects against nukes, whereas Bunker does reduce air damage. Therefore, Bunker (now at Steel) is assumed to represent both bunkers and air raid shelters, and Bomb Shelter is renamed.
- Steel is required for blast doors; if not in civil defense shelters, then in shelters for military equipment (the building also reduces damage to military units). Medicine could be needed for understanding the impact of radiation on the human body, and the tech has room. 178 This has no tech requirement in BtS, but is only available for Great Warlords. Quick free healing shouldn't be available in the early game, and the first couple of Great Generals shouldn't always be used for 'super medics". See also stat-changes.pdf. Plus, the Medicine tech
- needs a buff. 179 Merging Democracy, Communism and Fascism into just two techs (Equality and Totalitarianism) opens up room for a new technology. It's a military technology because there are so many military units in the Industrial era, and several of them with unrealistic tech requirements; Machine Gun at Railroad even seems completely nonsensical. The "Rapid Fire" tech represents advances in firearms from the late 19th century, especially smokeless powder and mechanisms for absorbing or redirecting recoil. Physics is required for the recoil handling (Newton's laws of motion), and Steel because all the firearms in ques-

tion were mass-produced in steel. (Ideally, Biology should be required

for the smokeless powder, but that would be one tech requirement too

- I've got the name "Rapid Fire" from the American Revolution Mod; the tech icon would also come from there.
- 180 New name for the Artillery unit to allow me to move it to Rapid Fire. Several WW2 units move to the Artillery tech, and the Artillery unit should come earlier than these units. The Canon de 75, regarded as the first modern artillery piece, was a quick-firing field gun with a hydropneumatic recoil mechanism, so Rapid Fire is a suitable requirement. (Machine guns and field guns developed alongside each other, differing in caliber and fire rate.) The name "Ballistics" for the Artillery tech should make clear why Field Gun comes earlier: field guns were not designed for indirect fire. Accordingly, Mobile Artillery gets named
- "Howitzer". 181 No tech required in BtS. Apart from Air units, Gunpowder units can get this promotion in BtS, and I'm also allowing it for Siege and Naval units (see stat-changes.pdf). Not plausible to hit aircraft with slowfiring guns. And I don't want the promotion to show up on the UI long before it is needed.
- 182 No tech requirement in BtS. Don't want this to show up on the UI long before Armored units become available. Military Studies could be an alternative, but comes a bit too early.
- 183 Moved from Fascism (now called Totalitarianism). The developers may have seen the memorial as a response to fascism, but that's easy to The synthesis of nitroglycerine (1847) was important for both the development of smokeless powder for firearms, and dynamite, which was used extensively in the construction of the Mount Rushmore
- 184 Coal Plant moves to Electricity, Pentagon to Industrialism and Infantry to Rapid Fire (new tech), though Assembly Line remains required. 185 See stat-changes.pdf about these resource requirements. 186 The 3D model, apparently, shows a WW2 US soldier with an M1 rifle (in service since 1936). This kind of unit comes a bit too early in BtS; the Rapid Fire requirement delays it. The Infantry unit would otherwise also replace Rifleman too soon now that Rifling is an Industrial-era
- tech. The M1 is a semi-automatic (gas-operated) rifle, so requiring Rapid Fire is also historically sound. 187 Equality replaces Democracy. Assembly Line becomes an additional requirement because this makes it easier to explain the production bonus for Towns: an increase of female participation in the industrial workforce tended to precede female suffrage.

as an additional requirement instead of vice versa.

An Industrial-era tech because submarines were already deployed in WW1, and the Eiffel Tower was completed in 1889. 189 Attack Submarine and Nuclear Submarine (previously just called "Submarine") have switched places. Attack Submarine was introduced in BtS as a counter against the vanilla Submarine unit, probably representing early Cold War hunter-killer designs. This role is too narrow.

88 Cristo Redentor moves to Steel (q.v.) and Bomber to Flight with Radio

- Instead, Attack Submarine becomes the ordinary submarine unit for the World Wars, and Nuclear Submarine a more expensive unit representing the cruise missile and ballistic missile subs of the Cold War 190 Moved from Physics, which is now a Renaissance tech and thus way too early for revealing Uranium. The radioactive properties of uranium were discovered in 1898, and, around that time, uranium began to be
- mined for extracting radium. Radio directly leads to Fission now (not required for Fission in BtS), meaning that Uranium becomes useful shortly after it is revealed, which could be unfair to civs without Uranium. That said, Uranium only becomes crucial once and if the Manhattan Project is built 191 Radio is also required for all naval units that detect Submarines. This should make early Submarines more dangerous. Even with Radio, Air

Recon should only reveal Submarines that are adjacent to another ship.

(A submarine spotted on the surface by an aircraft will dive and change

- its position if it isn't promptly engaged.) Too easy in BtS to spot Submarines with air units. 22 Requires Rapid Fire for the machine guns mounted on Fighter. No Carrier without Fighter, and Paratrooper also carries an automatic rifle. The Rapid Fire tech covers nitroglycerine and other high explosives, so Bomber needs it too. No need to require Combustion as Fighter and Bomber require Oil. Airport moves to Advanced Flight (q.v.).
- I'm drawing the line between Industrial and Modern era in the late 1930s. This yields a pretty even distribution of techs. Flight could really go either way: The 3D models appear to show planes introduced in the 30s (Spitfire, B-17). 193 Still requires Radio (for search radar) and Flight, but since both are in the same column now, Flight as the more obvious requirement becomes

the main requirement. (Radio is also pretty crowded.)

hardly a matter of ideology.

- 194 By the 1930s, when bombers became potent, practically all military aircraft had aluminium in their airframes. One could argue that Aluminum (or just Electricity) should then also be required for Fighter. British WW1 fighters had wooden fuselages, but (usually?) also included aluminium components, and the Fighter unit is arguably too powerful to represent WW1 technology. However, a civ without Fighter would be without any adequate air defense; this might be too punishing. 195 Moved from Fascism (now called Totalitarianism). Fascist Italy and Germany were early adopters of airborne infantry, but parachuting is
- 196 New name for the Artillery tech; see Field Gun (new name for the Artillery unit) at Rapid Fire about the name change. One could also look at Rapid Fire as "Artillery I" and Ballistics as "Artillery II". One important advancement at Ballistics is indirect fire. Three units move to Ballistics that don't require Artillery in BtS, but represent artillery platforms: Tank, Destroyer and Battleship. Anti-Tank
- moves from Artillery to Rocketry (q.v.). 197 Destroyer is at Combustion in BtS and Battleship at Industrialism. The former is too early, leaving too little time for Ironclad, and the latter rather too late, skipping the Dreadnought era. Radio is required for spotting Submarines. I don't see a problem with Destroyer coming later (or at least no earlier) than Battleship; Destroyer has a distinct role as an anti-Air, anti-Submarine unit. (I'm intending to make Battleship a bit more vulnerable to aircraft and subs; see stat-changes.pdf).
- As for the resource requirements, Industrial-era ships are allowed to run on Coal, but move faster with Oil. This should fill a gap between coalfueled (early) ironclads and oil-fueled WW2 navies, and make early access to Oil less crucial. This, in turn, should allow for a more realistic, namely clustered, placement of Oil resources during map 198 Moved from Industrialism; that would be a bit much on top of
- Ballistics, and the manufacturing process is covered by requiring Assembly Line instead of Industrialism. Railroad is needed for the vehicle's continuous tracks, a crucial innovation that was inspired by railroads. (An early patent was named "endless railway".)
- 199 Look at this tech as the last stage of the Second Industrial Revolution combining assembly lines with electrification and steelmaking. Steel (not required in BtS) should perhaps already be required for Assembly Line, but certainly for Industrialism. One could also argue for Combustion as a requirement (petrochemistry, chemical industry), but it would be one requirement too many, and is required for Plastics in the
- next column anyway (also in BtS). Tank and Battleship have moved to Ballistics (q.v.; formerly Artillery). Aluminum is revealed by Electricity instead of Industrialism. Ivory goes obsolete with Ecology instead of Industrialism. 200 Requires the new Rapid Fire tech instead of just Rifling. The 3D model appears to show an AK-47.

ing that Industrialism is a good match. It's also nice to have Marine and

Transport at the same tech.

Uranium is no longer an alternative requirement; nuclear reactors in

troop transports wouldn't be economical. Same for Destroyer (at Ballistics). 202 Moved from Assembly Line. The construction of the Pentagon was completed in 1941, so Assembly Line is a bit early, and there isn't much of a connection. At Industrialism, the Pentagon can represent the

military-industrial complex

- 203 Moved from Rocketry, mostly, because that tech doesn't have room 204 Replacement for Fascism, also taking over parts of Communism (which is otherwise replaced by Equality). Totalitarianism requires Equality for the element of collectivism (perhaps debatable). As "Fascism", there was too little that the tech could plausibly do, considering that it's a
- dead end in the tech tree. Paratrooper has moved to Flight and Mount Rushmore to the new Rapid Fire tech. 205 The spy stuff is a pretty silly way to represent communism in the game; fits much better under the label "Totalitarianism". The free Great General is, for now, entirely removed. There's also no tech granting a free Great Prophet, so I think this is fine. The new

"Statecraft" tech (replacing Civil Service) is a good candidate for a free

- Great General and could even be renamed to "Strategy", but would arguably become too powerful that way. 206 For consistency, all pre-Medieval wonders should go obsolete at some point if there isn't a special reason against obsoletion. At Totalitarianism, all government civics are guaranteed to be unlocked, and obsoleting a symbol of democracy boosts the evil image of Totalitarianism. 207 Replacing the speed bonus for ships. A big speed boost came from steam turbines, but I don't think refrigeration had any part in this. Moreover, the speed bonus makes it harder for players to keep track of how far each ship can move in one turn. (For the same reason, the circumnavigation bonus should be replaced with some other perk.) As for the new ability: The amount of food provided by Fishing Boats in the early game is highly unrealistic. That food output needs to be reduced by 1 (see stat-changes.pdf), and then Refrigeration brings
- developments in commercial fishing that BtS fails to capture. (This change is inspired by the Civ 4 Reimagined mod.) 208 Moved from Medicine and replacing Cereal Mills, which moves to

the bonus could also represent trawling, fish farms and other

the output to the same level as in BtS. Apart from food conservation,

Biology (q.v.). Refrigeration is a better explanation for a seafood company than healthy diets. 209 The nonsensical Plastics requirement was added by the BtS expansion, presumably for balance reasons. Not much of a point in obsoletions this late in the game, and the Medieval wonders University of Sankore and Spiral Minaret come so

late that they don't need to go obsolete at all. Angkor Wat has moved to

Aesthetics though, and most Classical-era wonders do go obsolete; now happens at Scientific Method. 210 Internet moves to Fiber Optics (q.v.), so Computers needs a new ability. The processes, Research, Wealth and Culture, are too powerful in BtS. Set the conversion rate to 80% initially, and to 100% (as in BtS) only with Computers. This ability could make Computers one of several techs to beeline to when aiming at a Space victory.

211 Moved from Ecology, which is no longer a Modern tech. For consis-

tency, the main tech requirements of SS parts should be Modern or Future techs. BtS, is the only building that benefits from electrical power. Now there 212 Same as in BtS. Could be explained with advertisements, particularly "a diamond is forever" by De Beers. 213 Requires Ballistics (replacement for Artillery) instead of Flight or Artillery. Rocketry is a subfield of ballistics, so Ballistics has to be required. Perhaps Flight should be required in addition, but supersonic

subsonic aerodynamics relevant for constructing planes. Only

combustion engines.

aerodynamics seem to be quite different from (and less tricky than) the

Combustion is required instead; rocket engines are normally internal

Aluminum Co. has moved to Industrialism in order to make room at

214 MANPADS only became effective in the 60s through infrared homing. Require Radio for that. (Infrared is a type of radiation.) The first Modern column would otherwise be a bit early for such a unit. 215 Civilopedia talks about "high-velocity cannons", but the combat animations show a shaped-charge warhead fired from a recoilless gun. Recoilless guns exhaust gas like rocket launchers. Shaped charges are

also needed for initiating nuclear explosions (explosive lens). It's

- convenient to assume that Rocketry covers this because Rocketry is required for nukes anyway. 6 Moved from Robotics. Not much of a point in such a late unit, and I doubt that robotics has anything to do with missile cruisers. Practically no Battleships were commissioned after WW2, so Battleship should not remain without a replacement for so long. Radio as an additional requirement because just Rocketry would be a bit too early. I'm also
  - 217 Hydroplant and Three Gorges Dam move to Electricity and Standard Ethanol to Combustion 218 This ability should represent containerization, and help coastal cities in the late game. BtS gives coastal cities practically no bonuses during the

adding an air interception chance (missile cruisers developed from anti-

air cruisers and continued to have air defenses); Radio could be needed

Industrial and Modern era. This really has nothing to do with synthetic materials, but Plastics comes at the right time and otherwise does too 219 This bonus mirrors the health bonus at Genetics and should make up for the resource obsoletions at Plastics and in the Industrial era (Whale, Dye, Ivory). Plastics have improved numerous consumer goods or made

220 Oil appears only on Ocean tiles, so this tile improvement should really

be about deep-sea drilling. Synthetic materials are probably used for this, e.g. for tubes and pontoons, but I doubt that they're really needed. Hard to find a more plausible place for Offshore Platform though. 221 Part of an effort to make resources less crucial for city growth in the

them affordable.

- late game. The importance of silk declined after the development of 222 Requires Radio for the radioactivity (only Electricity in BtS). 223 Requires Satellites instead of just Rocketry because Satellites is the spaceflight tech now. 224 The Satellites requirement (supposedly for satellite guidance) moves down the tree to Stealth; instead require only Rocketry for Advanced Flight. That's for the advanced engines (turbojet, turboshaft).
- to justify an extra trade route from Airport. Radio navigation and radar (landing guidance) was important for flight safety in passenger aviation 226 This should really happen at Rocketry because Cavalry upgrades to Tank and Anti-Tank now instead of Gunship (see stat-changes.pdf), meaning that Cavalry is normally obsoleted by Rocketry (which now enables Anti-Tank). But there is only enough room left for either Stable

225 Moved from Flight. Strategic airlift without jet aircraft is difficult to

imagine. The commercial use of planes was also too small prior to jets

or Horse at Rocketry, and both should go obsolete together in order to 227 Now requires Computers (only Radio in BtS). It might be possible to launch a satellite without (electronic) computers, but there were computers at the Baikonur Cosmodrome when Sputnik 1 was launched. The Apollo Project is inconceivable without computers 228 Moved from Rocketry and replacing Docking Bay, which moves to

Robotics. Rocketry should not include spaceflight because this

addition to Plastics and the hidden Computers requirement for the

overloads the Rocketry tech, and because an ICBM (first launched 1957) is a much greater technological achievement than a guided missile staying within the Earth's atmosphere. Plastics is required for e.g. insulation. One could also argue for Refrigeration because of heat exchangers in space suits, but that would be a third requirement not indicated by arrows in the tech tree (in

Satellites tech).

expansion).

- 229 Moved from Laser. Don't want to require the combination of Satellites and Laser for both SDI and Space Elevator (moved to Laser from Robotics). The present-day measures of the Missile Defense Agency (successor of the SDI) don't seem to rely on lasers, although lasers might be incorporated within the next decade. The BtS expansion had added the Laser requirement. 230 Removed the Satellites requirement. Radio (for stimulating the emission) and Plastics (for synthetic crystals) are reasonable
- military units enabled by Laser. Neither the Avenger described in the Civilopedia entry for Mobile SAM, nor the Patriot that the 3D model resembles, nor the M109 howitzer shown by the Mobile Artillery model appear to rely on satellites for aim or homing. They do employ lasers as rangerfinders, and the M109 can also fire a laser-guided shell. 231 New name for the Mobile Artillery; see "Field Gun" at the new "Rapid Fire" tech about the name change. The 3D model shows a self-propelled

requirements, but Satellites should only be required for SDI, not the

- 232 Moved from Robotics, and taking the spot of SDI, which moves to Satellites. Perhaps the climber component could be a robot, but I doubt it. Laser could be needed for powering the elevator and for producing nanomaterials for the cable. 233 Removed the Satellites requirement. Probably a remnant from when Jet Fighter and Stealth Bomber were at Composites (prior to the BtS
- 234 Moved from Robotics because I don't see any connection between Mechanized Infantry and Robotics. The 3D model shows an M113; these first entered service in 1960. The armor is not made from a composite material, but an aluminium alloy. Some infantry rifles from the 60s have fiberglass stocks (e.g. M14, M16), and the Humvee has composite armor. The new Rapid Fire tech is required for the select-fire rifles. 235 The 3D model shows an M60. That's an early second-generation tank without composite armor (just steel). It's also not ideal to have Modern

Armor and Mechanized Infantry at the same tech. Hard to find a

different place for either unit though. The additional requirement of

- Laser for Modern Armor should help a bit. The M60, or at least many variants of it, had a laser rangefinder. Also, the T64 tank, contemporary with the M60, did have composite armor, and so do all third-generation tanks. Ballistics (replacement for Artillery) is required for the tank gun. Certainly no Aluminum should be required for a heavy tank. 236 New name for Laboratory. The BtS expansion moved this building from Computers to Superconductors. It's still too easy to access, making Superconductors a beeline target for a Space victory too often, and the name "Laboratory" doesn't explain the Superconductors requirement well. Particle accelerators use superconducting magnets, and particle
- physics justify Fission as an additional requirement. I'm requiring Computers only for Particle Accelerator, not for Superconductors, because the important theoretical discoveries about superconductivity in the 50s and 60s did not hinge on computers. 237 Replacing the Superconductors requirement with Computers because I see no connection between genetics and superconductors. If the Genetics tech covers recent advances like genetical engineering, gene therapy and the Human Genome Project, then computers are needed for

238 A stasis chamber should be based on cryonics, i.e. Refrigeration (also

Genetics should be a SS tech, so let's imagine that only genetically

required in BtS via Superconductors) plus Medicine. But I guess

DNA sequence assembly.

engineered humans can endure cryostasis.

- 239 Three health would exaggerate the effects of genetics on human health compared with other 20<sup>th</sup> century advances like vaccination or antibiotics that are, supposedly, represented by the three health from Hospital. Instead, give Genetics a food bonus representing highyielding crop varieties and gene food. One extra food for all Farms would be way too much, hence the restriction to high-food tiles like Corn ( $\rightarrow$  gene maize). The food bonus should also make the health bonus more valuable: it counters the bad health from population
- connection with robotics; moved to Composites and Rocketry. The Space Elevator also doesn't make much sense at Robotics; moved to Laser. Rather give Robotics a SS part. Since the Apollo Project moves to Satellites, the Docking Bay is available. I'm sure there is some way in which e.g. robotic arms could be useful in a docking bay. Prior to the BtS expansion, Docking Bay was also at Robotics. The bonus to Industrial Park represents industrial robots; hence also the rialism requirement for Robotics. Prior to Robotics, Industria

240 Neither Mechanized Infantry nor Missile Cruiser have a plausible

changes.pdf for details. This is part of an effort to reduce the production output of industrialized cities. 241 Requires Satellites instead of Advanced Flight; the latter shouldn't be required for Stealth Destroyer. The B-2 shown in the Stealth Bomber 3D model can drop satellite-guided bombs, and there are probably other ways too in which these high-tech units use satellite navigation. Don't want Satellites to be a dead end (no longer leads to Laser), and geolocation through satellites should have *some* military benefit in the game.

(BtS requires Satellites already for Advanced Flight.)

Park mostly gets the abilities of an electrified Factory; see stat-

242 As with Submarines (see Radio), the Recon mission should only reveal stealth ships adjacent to another ship. Allowing only Stealth Destroyers to detect Stealth Destroyers is pretty silly. Surely, the Stealth Destroyer's (phased-array?) radar system can also be installed on aircraft (and on other ships, but let's keep it simple). 243 No obsoletion of Kremlin; pointless this late.

244 Moved from Computers in order to make Fiber Optics more attractive.

Had already been at Fiber Optics prior to the BtS expansion.

245 Requires Fiber Optics instead of Stealth because Fiber Optics would otherwise be a dead end (no longer required for Fusion), and because fiber optics (with its uses in computer networks) seems more likely than stealth technology to lead to future innovations that increase people's happiness and health. 246 Requires Superconductors instead of Fiber Optics because Superconductors would otherwise be a dead end (no longer required for

Genetics). Also, magnetic confinement is the main approach toward

superconductors. 247 That Engineer is fairly useless in BtS as there are few if any worthwhile wonders this late in the game. Can now also be used on SS parts (see Great Engineer in stat-changes.pdf).

fusion energy, though the magnets probably don't have to be

the Line (which can't take down Transports). The 3D model shows a WW2 landing craft. These aren't oceangoing, but the unit could represent the contemporary Liberty and Victory ships, which according to Wikipedia, "came to symbolize U.S. wartime industrial output", mean-