Global Change

as Demonstrated by Aviation
Climate, Resources, Globalization, and Demographics

Solutions to Teaching Materials

for Upper-level Classes at the Bavarian *Gymnasium*

Geography

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Contents

1 Global Player from Germany – The Example of MTU Aero Engines

Teaching materials: pgs. 5-6

R1: Does MTU Aero Engines qualify as a "global player"? Consult Figure 3 and your textbook. Assess.

- Participates in the global competition: Yes, the aero engine business is dominated worldwide by a small group of companies, among them MTU.
- Enjoys a leading position in its industry (technological, qualitative, and innovative leader): Yes, MTU has the leading technology in low-pressure turbines, high-pressure compressors, and high-tech production processes.
- Exerts influence on politics and market mechanisms: No, as an original design manufacturer (ODM) with fewer than 10,000 employees worldwide, MTU is not powerful enough to influence politics or market mechanisms.
- Has subsidiaries around the world: Yes, MTU is represented on all continents other than Australia and Antarctica.
- Has financial power like that of a small country: No.
- (further criteria from relevant sources)

R2: How globalized is the commercial aero engine business? Research where the aero engine and aircraft manufacturers named in this chapter have their headquarters. Also research the headquarters of Boeing, MRJ, and Cessna. Explain your answer.

The commercial aero engines business is globalized because aero engine manufacturers, aircraft manufacturers and airlines are spread out around the world:

- Aero engine manufacturers: P&W (USA and Canada), GE (USA), RR (Great Britain), MTU (Germany), Safran-Snecma (France), GKN (Great Britain), Avio (Italy)
- Aircraft manufacturers: Airbus (Europe), Boeing (USA), Bombardier (Canada), Embraer (Brazil), UAC (Russia), MRJ (Japan), Cessna (USA)
- Airlines: worldwide

R3: Aero engines are transported to MRO locations over long distances – from an airline's base on the Persian Gulf, for instance, to MTU Maintenance in Hanover. The transport alone can cost more than 10,000 U.S. dollars. Does transporting engines over such long distances make sense? Assess this practice from an economic and from an ecological perspective.

- Economic perspective: Transport costs form a negligible part of the total MRO costs. Transport time is also negligible on the scale of the total duration of the MRO process. What matters most is quality – which MTU, with its leading technologies, can guarantee.
- Ecological perspective: At first glance, transporting an engine over such distances doesn't seem prudent. Yet by servicing the engine, MTU can optimize its efficiency and reduce its CO_2 emissions. Hence the energy expended in the transport can be amortized while the engine is running between maintenance breaks. In the long term, it could make economic sense – especially in the light of rising fuel prices – for MTU to set up additional maintenance locations near some of its principal customers.

R4: Why are MTU's IGT service centers (F4) located where they are? Consult relevant atlas maps. Thoroughly justify your answer.

MTU's IGT service centers are characterized by:

- Proximity to petroleum and natural gas production sites:
  - USA: West Texas, Gulf Coast
  - Oslo: the North Sea
  - São Paolo: the Atlantic Ocean, near the Brazilian coast
  - Bangkok: Brunei, Malaysia, and Indonesia
- Central locations: Service centers do not need to be placed in the middle of petroleum or gas extraction areas, but can be established instead in the nearest population center of international importance. This allows them to benefit from agglomeration effects.

2 Atmosphere and Aviation

2.1 Workings of an Aero Engine

2.2 The Influence of Temperature and Atmospheric Pressure

Teaching materials: pgs. 8-10

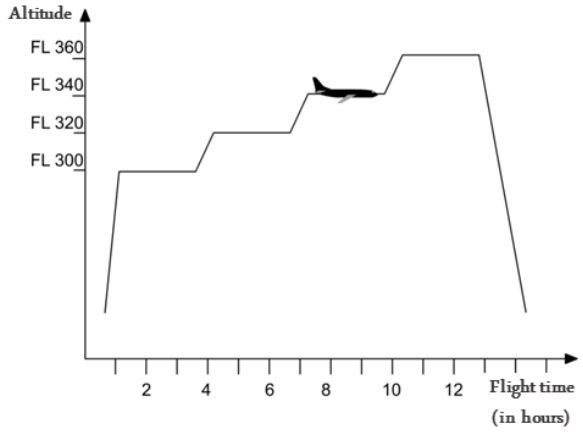
R1: Why does an airplane continue to gain altitude throughout a long commercial flight? Justify your answer.

The airplane is carrying fuel to fire its engines. As the fuel burns, the airplane becomes lighter, i.e., the force of gravity is reduced and lift increases. Hence the airplane rises automatically. The airline wants the plane to rise until it reaches the optimal cruise altitude of about 11,000 m. Here the engines operate with the highest degree of efficiency, and the plane can reach its cruising velocity. That also shortens the flight time, meaning the airline can use the plane again sooner. Ultimately, therefore, the airline's return on the plane as a capital investment rises along with the plane.

R2: Why is an airplane's ascent during cruise flight generally executed as step climb rather than a cruise climb, even though the latter would conserve more fuel? Explain.

There is considerable traffic along most flight routes. Hence air-traffic control assigns each airplane to a certain flight level, and the planes may not leave their levels without permission. This practice prevents collisions.

R3: Redraw Figure 4 to show a step climb encompassing four flight levels.



Step climb (source: Wikimedia)

R4: Why are atmospheric conditions most suitable for cruise flight at an altitude of 11,000 m? Explain.

Up to this altitude, the loss in engine performance due to reduced air pressure (a negative influence) is compensated by gain in performance due to reduced air temperature (a positive influence). Above 11,000 m, however, air pressure continues to fall while air temperature remains constant, and so engine efficiency begins to decline. If the airplane nevertheless continues climbing, the steady loss in engine performance (due to steadily falling air pressure) will eventually prevent it from generating any further lift. At this point, the airplane will have reached its service ceiling.

R5: What other advantages does a cruising altitude of 9,000 to 11,000 m offer as opposed to a lower altitude of, say, 2,000 to 5,000 m?

The advantages are:

- Passing over mountains
- Passing over thunderstorms
- Using the jet stream
- Maintaining separation (an appropriate safety margin) from aircraft in the takeoff or landing phase at airfields
- Preventing aircraft noise from reaching ground level

2.3 The Influence of Volcanic Ash

Teaching materials: pgs. 11-12

R1: Why did air safety officials pronounce a general flight ban after the eruption of Eyjafjallajökull, even though the ash cloud did not rise high enough to affect cruising altitude (9,000 to 11,000 m)? Justify your answer. Present multiple safety considerations.

- It would be possible for the ash cloud to reach cruising altitude at any time, e.g. in the event of turbulent winds. The expansion of an ash cloud is difficult to predict.
- Airplanes also fly below cruising altitude – during takeoff and landing, for instance.
- Even an airplane that intended to pass over the entire area affected by the ash cloud might need to make an unplanned landing. Hence planes were not allowed to fly over the ash cloud.

R2: Execute a roleplaying scenario in which air-traffic control authorities and airline representatives argue about the flight ban during the first days after the spread of the ash cloud.

Talking points:

- Air-safety officials: We've known since the incident with KLM Flight 867 that volcanic ash can put airplanes in danger or even cause a crash. Safety is the highest priority; we'd rather err on the side of caution and pronounce a no-fly zone that's too big rather than one that's too little, etc.
- Airline representatives: There is no proof of any risk to air traffic outside the immediate vicinity of Iceland. The concentration of ash particles in the air is quite low. The economic damage of the flight ban, on the other hand, is enormous. European airlines are at a competitive disadvantage against other airlines less affected by the flight ban. Many flight passengers have been stranded, while other modes of transportation are now overburdened. Customers are losing their trust in the airplane as a mode of transportation, etc.

R3: Estimate which flight routes are most at risk from volcanic ash (tephra). Consult sources on historical and current volcanic activity as well as Figure 12.

Links: earthquakes.volcanodiscovery.com; www.volcano.si.edu/weekly_report.cfm

- The volcanoes that tend to produce ash clouds are the ones covered by glaciers (Iceland, Antarctica) and the stratovolcanoes around the circum-Pacific Ring of Fire. They present the greatest risk.
- The North Atlantic route over Iceland is heavily frequented. Eruptions leading to ash clouds are rare, however, so the risk is relatively low.
- One finds both heavy air traffic and a number of dangerous volcanoes on the west coast of North America, on the east coast of East Asia, and along the Indonesian Archipelago. This is where the risk is greatest.

R4: Trace the routes of KLM Flight 867 (F1) and of the non-stop connection from Amsterdam to Tokyo on a relevant atlas map. Why has the direct route, without any stopover, been used only since the beginning of the 1990s? Explain.

- Map: azimuthal projection of the Arctic region
- The route by way of Anchorage represents a significant detour in comparison to the Amsterdam-Tokyo flight path. This detour allows the plane to avoid Russian airspace.
- The Soviet Union continued to exist until the early 1990s. From the end of World War II until the end of the "Cold War," planes from Western countries were generally not allowed to fly over territory belonging to member states of the Warsaw Pact.

2.4 The Influence of Aeolian Sand

Teaching materials: pgs. 13-14

R1: What geographic location is shownd in the satellite image (F7)? Draw a sketch showing this region in its physical-geographical surroundings. Use relevant atlas maps to determine the season in which the image was captured.

- Location: northern Persian Gulf
- Sketch: Arabian Desert to the west and in the center; Zagros Mountains to the southeast and northeast; Persian Gulf to the east and in the center; Tigris-Euphrates Delta to the northwest
- Season: northwest wind (movement of sand clouds; clouds rising along the Zagros Mountains). The satellite image was taken in the summer. The wind is shown blowing towards the low-pressure area that forms over the Iranian plateau during the summer months.

R2: Describe the volcanic ash and aeolian sand in Figures 10 and 11 with regard to their relative shapes and particle sizes. Support your observations by describing the conditions under which each of these substances was formed. Why is the abrasive effect of volcanic ash stronger than that of aeolian sand? Justify your answer.

- Volcanic ash: Particles are for the most part very small, having formed when a mass of volcanic rock was blown apart in a powerful explosion. Larger particles are angular and were probably torn away from rock that had already solidified.
- Aeolian sand: Particles are homogenous in size and larger than the volcanic ash particles. They are angular, having formed by frost weathering under arid conditions. They have also been transported by aeolian forces, causing them to further disintegrate. If the sand had originated in a humid area and had undergone fluvial transport, the particles would be smooth from rubbing together under water.
- Abrasive action: The volcanic ash is made up of very small particles not likely to break down any further. Thus they strike against the compressor blades with the full force of their kinetic energy. The aeolian sand particles, on the other hand, break apart upon impact, losing a portion of their kinetic energy in the process. Hence their effect on the blades is less severe.

R3: Which regions and commercial flight routes are most affected by aeolian sand? Assess. Consult relevant atlas maps and Figure 12. Also consider the growth of air traffic, paying additional attention to the regions where strong growth is expected.

Maps showing desertification and vegetation:

- Flight routes overlap with arid regions in the low and middle latitudes: the Southwest of the USA, the Iberian Peninsula, Turkey, the Levant, the Persian Gulf region, the Central Asian Republics, India, and Northeast China.
- Areas that will be affected more strongly in the future: the Persian Gulf region, India, Northeast China, and desert regions in Northwest China.

R4: Where do the German and U.S. militaries currently have troops and aircraft deployed in assignment abroad and/or combat operations? Do research. Estimate of the relative threat of erosion by aeolian sand at each location.

Erosion by aeolian sand is highly relevant for both countries' air forces:

- USA: missions in Afghanistan, Iraq
- Germany: missions in Afghanistan, Mali, ...

R5: How do volcanic ash and aeolian sand affect aero engines? Provide a brief summary of the effects of each, and assess which represents the greater threat for routine aviation.

Volcanic ash:

- Erodes compressors
- Melts and collects in the turbine as a molten mass
- Increases fuel consumption and can cause engine failure
- Is less of a danger for routine aviation, since ash clouds occur only rarely. And since scientists can detect when a volcanic eruption is imminent, flight crews can be warned in time to avoid the ash cloud.

Aeolian sand:

- Erodes compressors
- Increases fuel consumption
- Is a constant danger in arid regions at low and middle latitudes

3 Water and Energy Use at MTU Aero Engines Headquarters in Munich

3.1 Local Conditions

Teaching materials: pgs. 15-16

R1: Locate the MTU factory grounds (F1) on a small-scale atlas map or (with your teacher's permission) using your mobile phone.

E.g.: Diercke World Atlas 2008, Map 46: Alpine foothills/commerce and industry, grid square B2
(Diercke-Weltaltas 2008, Karte 46: Alpenvorland/Wirtschaft, Planquadrat B2)

- Symbols for a mechanical engineering firm (MTU) and an automaker (MAN)
- southeast of Karlsfeld, north of the highway, east of the railway line to Dachau

R2: Draw a land-use diagram showing the structure of the area depicted in Figure 1. What are the favorable and unfavorable aspects of this location from the standpoint of MTU? From the standpoint of the local population? Explain.

- Sketch: structured by transportation routes; differentiation shown between residential areas (detached houses, housing blocks), agricultural areas, industrial areas, forested areas, and traffic areas
- Local population:
    - Favorable: proximity to transportation infrastructure (beltway, arterial road to Munich, train station), to industrial jobs at MTU and MAN, and to the Allach Forest, a local recreational area; outskirts of the city, with agricultural land just to the north
    - Unfavorable: noise and exhaust emissions from local traffic and industry; traffic from commuters employed in local industry
- MTU:
    - Favorable: good transportation connections; workers who live nearby don't have to commute to the city; good access to the airport; immediate surroundings not sensitive to noise emissions (highway to the south, Dachauer Straße with open areas and an industrial park to the east, MAN to the north and west)
    - Unfavorable: no room to expand

R3: An input-output analysis (F2) measures the supply and material flows and the emissions that a company generates within its own facilities in manufacturing its products and/or rendering its services. The analysis does not include the commuter traffic generated by the company's workers. With a partner, estimate how many total kilometers MTU's workforce commutes each year by means of private transportation. To obtain your answer, make plausible assumptions as to: the number of work days in a year, assuming that an employee is granted a total of 40 holidays and vacation days; the percentage of employees who work only three days per week, the percentage who work only four; the percentages who have, respectively, a 10 km, 30 km, or 50 km commute; the various means of transportation used for commuting, in their respective percentages; and the average sickness absence rate (percentage of employees who miss work due to illness).

21,689,184 km (ca. 22 million km) under the following assumptions:

- 4,600 employees; 220 work days per year; 10 % of employees work three days/week, 10 % work four days/week; one-way commuting distance: 50 % of employees travel 10 km, 30 % travel 30 km, 20 % travel 50 km; percentage of employees who commute in private vehicles: 50 %; average sickness absence rate: 5 %
- Total distance per year = 4,600 × (220×1×0.8+220×0.8×0.1+220×0.6×0.1) × (10×0.5+30×0.3+50×0.2) × 0.5 × 0.95

R4: Outline three approaches to reducing the amount of individual motorized commuter traffic generated by MTU's employees, and discuss the feasibility of each.

- Charging fees for parking: only commuters with a realistic alternative (public transportation, carpooling) will change their commuting habits; others will only be annoyed.
- Subsidizing tickets for employees with good access to public transportation: would create considerable costs; employees may choose to drive anyway.
- Company buses: MTU already operates two company bus routes within the Dachau district; expansion would create considerable costs.
- Shuttle buses to the nearest train station (*S-Bahn-Station Karlsfeld*): already in service.

3.2 Water as a Factor of Production

Teaching materials: pgs. 17-18

R1: Compare the water budget at MTU (F1) with the general water cycle (textbook depiction). How does MTU's water budget differ from that of a residential or agricultural area? Describe.

Differences at MTU:

- No evapotranspiration because factory grounds are mostly sealed (see satellite image)
- Groundwater used for cooling
- No surface water extraction
- Water used in production for: electroplating, cooling lubricants

R2: Look closely at Figures 1 and 3. Why is the quantity of wastewater MTU gives off greater than the quantity of drinking water it takes in? Explain.

Precipitation is discarded as wastewater. During heavy rainfall events (indicated by days with >20 mm precipitation), a lot of water flows into the sewer system before it has time to evaporate.

R3: What are the advantages and disadvantages of tighter water regulations from a citizen's standpoint? From a company's standpoint? Discuss.

Citizen's viewpoint:

- Disadvantages: may put domestic companies at a competitive disadvantage and thus endanger jobs if other countries pass looser environmental laws
- Advantages: health benefits; long-term assurance of a livable environment

Company's viewpoint:

- Disadvantages: costs
- Advantages: positive effect on corporate image; creates a competitive advantage if other countries raise their own environmental standards to a similar level (MTU will have more experience with necessary techniques)

3.3 Energy as a Factor of Production; CO_2 Emissions

Teaching materials: pg. 19

R1: Look closely at Figures 1 and 2. To what extent has MTU's energy use become more efficient over time? Explain. Also, determine which key figure would be suitable for calculating MTU's energy efficiency.

Energy consumption and CO_2 emissions have remained relatively constant, while output has increased.
Key figure: correct divisor is machine hours, as machines consume the most energy (number of employees is unsuitable because increasing mechanization and multiple machine operation means the number of employees per machine has fallen over time).

R2: With a partner, develop three ideas for achieving even greater sustainability in the selection and use of energy sources at MTU.

Using electric mobility on factory grounds; heating buildings with heat given off by IT equipment; conducting engine trials with computer simulations; expanding the capacity of the combined heat and power plant, etc. (These measures have all been considered and some are currently being implemented.)

R3: Why is vegetable oil shown in Figure 1, but not in Figure 2? Justify your answer.

Burning vegetable oil is CO_2 neutral because the plant consumes CO_2 in its growth phase through photosynthesis.

R4: In 2011, around 400,000 tons of CO_2 were released at the Munich Airport by airplanes in the landing and takeoff (LTO) cycle, in other words by air traffic below 3,000 feet (source: Munich Airport 2012). On that basis, calculate how many days it took in 2011 for the same amount of CO_2 to be released at the airport as was released in MTU's engine testing during the entire year.

(3,500/400,000) × 365 = 3.19375 days

R5: What are the effects of heating groundwater to 20 °C? Do research, and evaluate the practice of using groundwater for cooling purposes.

The practice has no negative effects on groundwater ecology. In fact it is beneficial for local residents who use heat pumps. In sum, very positive.

4 Mineral Resources and Aero Engine Construction

Teaching materials: pgs. 20-22

R1: Important deposits of nickel are found in central Brazil and on the Kola Peninsula and in Norilsk in Russia (F3). Locate these deposits on suitable atlas maps. What are the ecological implications of mining operations in these areas? Explain. Consider the carrying capacities of the surrounding ecosystems in your answer.

Localization:

- Brazil: Niquelândia (State of Goiás), Tucumã (State of Pará); potential natural vegetation: tropical rainforest
- Russia: Norilsk (northern Siberia), Kola Peninsula (Northwest Russia, near Finland); potential natural vegetation: tundra and boreal coniferous forest, respectively

Risks of mining:

- Obstructing vegetation with mine facilities and infrastructure; generating emissions through metalworking and energy production; introducing chemicals into the ground and surrounding bodies of water
- The carrying capacity of the local ecosystems is limited. In the colder zones, the cycle of matter is slower and the growing season shorter. In the tropical rainforest, removing vegetation can cause the soil to lose its nutrients and dry out.
- Ecosystems only regenerate to a limited extent – and very slowly.

R2: Why is the volume of nickel produced in some states disproportionately large with respect to reserves (F3)? Justify your answer. Also, what are the advantages and disadvantages of this mining policy as part of a certain development strategy? Discuss.

Indonesia and the Philippines produce for sale to nearby China, where the economic boom and the industrialization process continue to create significant demand. Also, both these nickel-producing countries are developing their own domestic metal industries.

- Advantage: quick source of foreign currency
- Disadvantages: no further value created within the country; economy becomes dependent upon the global commodities market

R3: Why does the aero engine maintenance field possess great potential for the sustainable use of mineral resources? Explain.

Every engine part repaired is one fewer that needs to be produced. That saves energy, water, and land that would otherwise be consumed in extracting and transporting raw materials and processing them into a finished engine.

R4: Why is it in MTU's interest to remain active in the maintenance business, with the raw materials of the metal cycle becoming ever scarcer? Justify your answer.

During maintenance work MTU obtains recyclable metals in the form of damaged engine parts. Once they've gone through the recycler, these parts can enter MTU's production process as a fresh batch. That gives MTU more security in its supply chain.

5 Energy Use in Aviation

Teaching materials: pgs. 23-26

R1: Figure 1 lists the factors that go into the aviation RFI. How does aviation affect the Earth's solar energy budget?

Student's textbook shows which radiation currents are affected.

R2: What challenges do we face in the effort to optimize air-traffic management? Make a list.

Safety:

- horizontal and vertical separation between aircraft
- precise timing
- runway capacities
- procedures in urgent cases
- allowance for weather

R3: Drawing on your knowledge of both geography and physics, prepare a presentation about CRISP technology and heat exchanger propfans for an interdisciplinary sequence with the physics department.

For ideas and information visit www.mtu.de

R4: What is meant by the total carbon footprint of an energy source? Explain using the example of biokerosene.

Total carbon footprint of biokerosene: account for emissions generated by

- Cultivation (seed production, vehicles, fertilizer)
- Conversion (production of biokerosene from biomass)
- Distribution (transport to the consumer)
- Use (burning)

R5: Draw and fill in an evaluation matrix for the alternative aviation fuel options shown in Figure 7. Under source, write the raw materials from which these fuels are produced. In the remaining squares, enter symbols showing whether the fuels are "attractive," "semi-attractive," or "unattractive" with respect to each category.

Fuel	Source	Energy density	Modifications	Technological maturity	Long-term availability	Global-warming potential
Kerosene	Petroleum					
BtL or HVO kerosene	Biomass					
StL kerosene	Solar radiation					
Liquid hydrogen	Solar radiation and water					
Electric battery	Solar radiation, wind					

attractive
semi-attractive
unattractive

R6: Why is the long-term global availability of raw biomass materials uncertain? Why are we unable to guarantee that these materials will always be produced sustainably on large tracts of land? Justify your answer.

- Long-term availability: There is competition for the use of agricultural land. Unoccupied land is becoming scarce because: 1) demand for foodstuffs is rising as the world population continues to grow; 2) land once suitable for agriculture is being lost to desertification due to climate change and unreformed farming practices; 3) urbanization and industrialization in emerging economies is causing agricultural land to be paved over or polluted.
- Sustainable production: threats to sustainable production include the use of pesticides and fertilizers, the clearing of primary forests, and the exploitation of agricultural workers.

R7: Why would electric flight be particularly sustainable given sufficient technological maturity? Justify your answer.

- No particulate emissions of any kind during flight, therefore also no RFI factor
- It would be technologically possible to produce the electricity with photovoltaic cells. That would take up a large land mass, but without altering the land chemically.

6 Economic Dynamic in Growth Areas – The Munich Airport Region

Teaching materials: pgs. 27-29

R1: Find indicators for economic dynamic in the greater Munich area on suitable atlas maps.

Indicators: low unemployment, high per-capita income, high purchasing power, etc.

R2: Figure 5 discusses where Munich's airport has been located at different points in time. Why were these locations chosen? Justify your answer by reference to a suitable urban development model.

Commercial suburbanization:

- It was necessary in each case to choose a location outside the urban area itself, since air traffic brings with it not only noise emissions but also the risk, however slight, of a crash. At the same time, the Munich Airport couldn't be unduly far away from Munich: the city had to remain accessible to its airport and vice versa.
- Here the airport followed the same pattern of commercial suburbanization typical of the industrial sector and, since the spread of personal car ownership during the 1960s, also of the services industry. The Oberwiesenfeld and Riem airports both lay at the edge of the city at their respective times of construction. Both were later integrated into the city and became residential areas in the course of 20th century urban growth (urbanization).
- When choosing a location for the new large-hub Munich Airport, it was possible to move farther out from the city's edge and accept a greater separation from downtown Munich. Mass car ownership and an expanded city railway system could be relied upon to ensure that the airport remained accessible.

R3: Look closely at Figure 2. What trends do you see for air cargo, airmail, and passenger volume since 1994? Discuss with a partner.

The flow of goods and passengers has intensified with the spread of globalization and the attendant rise in trade relations and tourism. Airmail has declined in volume, replaced by electronic communications.

R4: Figure 3 shows the distribution of business-related travel at MTU Aero Engines according to mode of transportation. Why are the kilometers distributed as they are? Explain.

- Predominance of air travel: international customers, suppliers, partners
- Cars: company cars are used mostly for commuting, rental cars and standby vehicles mostly for business-related travel within the region (i.e., within the Munich/Augsburg aviation cluster).
- High-speed trains for travel to Stuttgart, Frankfurt, Hanover

R5: What positive and negative effects does the airport have on its surroundings? Compile a list of pros and cons with a partner. Be sure to indicate whom the airport is in each case helping or harming.

Pros:

- Access to an airport with flights to worldwide destinations (businesses, residents)
- Influx of overnight guests, both business travelers and tourists (businesses)
- Job creation, at the airport itself and in the surrounding area (workers)
- Tax revenues (government)
- Economic policy leverage; growth and reinforcement of regional prosperity (government)

Cons:

- Increase in traffic on the ground, need for new roads (residents, government, ecosystem)
- Noise pollution (residents, ecosystem)
- Escalating real estate prices (residents, companies)
- Emissions such as CO_2, NO_x, etc. (ecosystem)
- Land consumption (ecosystem)

R6: Figure 8 shows where the Munich Airport's workers live. Interpret the geographic distribution.

- The majority live within a 40 km radius of the airport, with numbers decreasing as distance from the airport increases.
- Individual workers are interspersed throughout the rest of Bavaria (with a somewhat higher concentration in the agglomeration of Nuremberg, as befits the higher population density there). These are probably weekend commuters, students at local universities, and others who, despite working at the airport and renting an apartment in the area, continue to give another place as their primary address.

R7: Interpret Figure 10. With the aid of an atlas, draw a land-use diagram for the area depicted. Does geared turbofan technology have the potential to reconcile supporters and opponents of Munich-area air traffic (cf. R5)? Evaluate.

Land-use diagram:

- Traffic: airport with its two runways; highway to the north, parallel to the River Isar
- Water bodies: the River Isar, with riparian forest to the west and north
- Residential areas: Freising, northwest of the airport; Erding, east-southeast
- Agriculture: on the western half of the image primarily meadows and pastures (Erding Moor), on the eastern half cultivated land

Interpretation:

- The area affected by noise >75db is reduced significantly; Erding is no longer affected, even if wind conditions are not favorable, or if an airplane deviates slightly from its approach pattern.
- With other approach patterns the effect is similar: it becomes far less likely that Erding or Freising will be affected by engine noise.

Evaluation:

- Geared turbofan technology is a viable way to reduce noise pollution for local residents. The result should be less opposition to air traffic in general.
- Airplanes and aero engines have life spans of up to 40 years, so the noise reduction will become noticeable only gradually.

R8: Use the "STANLY Track" application (www.dfs.de) to chart flights at the Munich Airport currently under 3,000 feet.

Sketch: shows takeoff and landing patterns within a 20 to 30 km radius of the airport

7 Location Decisions in a Globalized World

7.1 Blisk Production at MTU Aero Engines in Munich

Teaching materials: pgs. 30-31

R1: Why did MTU choose Munich as the best place to locate its blisk production? Give a thorough explanation along the lines of Porter's theory of competitive advantages.

- Factor conditions: availability of the factors of production
  - Skilled workers: experts with many years' experience in research and development, programming, production planning, inspection, project management
  - Raw materials and energy resources: apparently available
  - Expert know-how, research institutes: MTU is networked with local colleges and universities
  - Capital and low capital costs: apparently available
  - Infrastructure for transportation and communication: very good; access to airport, highways
- Conditions for domestic demand: worldwide market, therefore not decisive
- Related and supporting industries: Munich/Augsburg aviation cluster
- Firm strategy, structure, and rivalry: differentiation strategy through quality and reliable delivery; international competitive environment, therefore also cost optimization
- Government: aviation research program of the Federal Ministry of Economics and Technology
- Chance events: enormous market success of the PW1000G engine

R2: What institutions, besides MTU, make up the Munich/Augsburg aviation and aerospace cluster? Do research. Name at least five other companies and three research institutes.

- Companies: Aerotech in Peißenberg, Cadcon in Gersthofen, Cassidian in Unterschleißheim and Manching, EADS in Taufkirchen/Ottobrunn, Eurocopter in Donauwörth, Eurojet in Hallbergmoos, IABG in Ottobrunn, Liebherr Aerospace in Lindenberg, MBDA in Schrobenhausen, MT Aerospace in Augsburg, Premium Aerotech in Augsburg, Ruag in Weßling
- Research institutes: Bauhaus Luftfahrt in Munich, BICAS in Taufkirchen/Ottobrunn, the German Aerospace Center (DLR) in Oberpfaffenhofen, the Augsburg University of Applied Sciences, the Munich University of Applied Sciences, the Technische Universität München, the Universität der Bundeswehr München

R3: Give a presentation about university degree programs in Aviation and Aerospace Engineering. Be certain to touch on the importance of this field for the German economy.

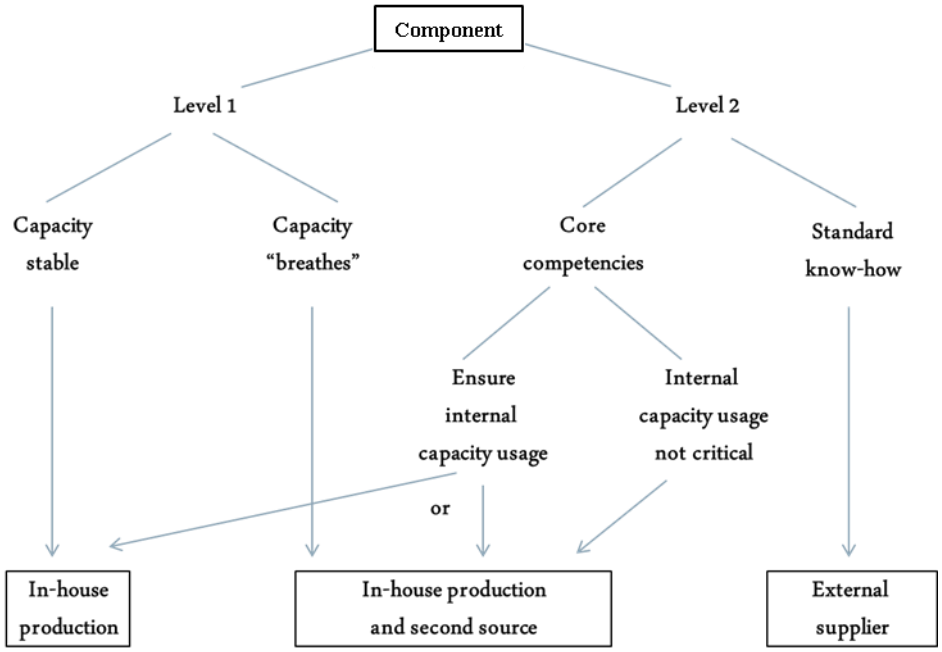
- Presentation as in "career and study orientation" class (*BuS-Unterricht*).
- Relevance for the Germany economy: supports many companies; creates key technologies for various processes in mechanical engineering, surface treatment, metallurgy, and automotive manufacturing, also for the growing aviation market, atmospheric research, satellite technology, etc.; ensures Germany's competitive advantages; sustains many jobs. For more information, visit the homepage of the German Aerospace Industries Association (BDLI): www.bdli.de

7.2 Production Strategy

Teaching materials: pg. 32

R1: Make a decision tree showing MTU's options for producing or purchasing parts. On the basis of your sketch, discuss the following assertion: "In international comparison, Germany is too expensive as a place of business."

Decision tree:



Discussion:
The assertion does not apply across the board. It is generally true regarding the production of level 2 products and other less sophisticated technologies, for example ones requiring a large degree of manual labor. However, even with level-two products, the "unit cost" argument must be qualified in some cases: if a German location's core competencies are involved, for instance, or if its machines aren't being used to capacity. With level-one products, Germany's advantages as a business location (see Porter's diamond model) are essential to achieving the desired product features, and extra costs can be regained through higher prices on the market. But even here it is important to produce as efficiently and cost-effectively as possible.

R2: What advantages does MTU's newly built Polish location offer in terms of production strategy? Explain. Make reference to your decision tree (R1) in your answer.

Advantages of production in Poland:

- Lower labor costs
- Retention of know-how
- Less dependence on external suppliers
- Security (company controls its own production)
- Capacities in Munich freed up for level-one production
- Positive effect on the company as a whole

7.3 Setting Up MTU Aero Engines Polska

Teaching materials: pgs. 33-35

R1: How many direct flights are offered at the Rzeszów Airport? Where to? Does the city enjoy a good position within the highway grid? Do research on Rzeszów, and evaluate its accessibility by airplane and commercial truck from MTU's locations in Munich, Hanover, and Berlin.

Direct flights (as of summer 2013):

- Germany: Frankfurt
- France: Paris; Great Britain: Birmingham, Bristol, East Midlands, Glasgow, London, Manchester; Ireland: Dublin; Italy: Rome, Trapani; Norway: Oslo; Poland: Warsaw; Spain: Barcelona

Accessibility:

- Air: Accessible by plane with a connection in Frankfurt or Warsaw.
- Road: Good accessibility. Coming from Hanover or Berlin, the roads run almost in a straight line, mostly highways. The route from Munich to Rzeszów is less direct, but also mostly highways. A truck leaving from any of MTU's German locations can easily reach Rzeszów within a day.

R2: Of all the commodity chains at MTU, which is the longest? Determine your answer with the aid of Figure 3 and a suitable atlas map. (Measure from the forge, to MTU, to the aircraft manufacturer, disregarding "second source" manufacturers and external component suppliers.) When you've found the longest chain, estimate its total length in a straight line.

Longest route:
USA - Israel - Munich - Rzeszów - USA - France: ca. 30,000 km
(Rough estimate, measured from the geographic middle of each country)

R3: What ecological or economic problems could result from MTU's globalized commodity chain? Work with a partner to compile a list, then compare your list to the problems in the globalized textiles industry, where most production steps are performed in developing countries (see your textbook).

- Ecological problems:
    - Long transport routes produce greenhouse gases and other harmful emissions. Also, in locations such as Mexico and Turkey, the use of water and chemicals could be less sustainable than in developed countries.
    - Comparison: MTU produces smaller piece counts than most textile companies; hence its total transport volume is much smaller. MTU also does not produce in third-world countries such as Bangladesh, but rather in places with stricter environmental laws. By complying with company standards, MTU's suppliers, including those in Mexico and Turkey, meet and even over-fulfill their countries' environmental laws.
- Social problems:
    - Utilizing low wages in places such as Turkey, Poland, and Mexico
    - Comparison: Unlike the textile industry, which employs unskilled workers and in some cases even children, aero engine production requires well-qualified specialists. Due to their expertise, these employees receive above-average wages in comparison to other industrial workers in their countries.

R4: Justify the criteria applied in the first filter of Figure 6. Why are they appropriate?

- EU: common tariff and legal system
- NATO: avoiding the many political and contractual restrictions that apply when military engine programs operate in non-NATO countries

R5: Why did MTU consider it essential that other aviation companies be present at its future location, even though it now has to compete with those same companies for workers? Justify your answer.

- MTU does have to compete for workers – not merely with other aviation companies, but with all companies in the metal-working industry.
- However, if it weren't for the other aviation companies in Rzeszów and the specialized job market they create, local universities and vocational training schools wouldn't offer the programs they do. That's why an ideal location needed to have a certain critical mass of similar companies, enough to exert an influence on the local education system.

R6: Review the first column of Figure 5. What specific points would MTU need to consider within each of these categories? Also, discuss how the categories are weighed (second column).

- Infrastructure – plot of land: shape and size, access to roads, topography, water table, contamination levels, zoning, building permit, current ownership, etc.
- Infrastructure – supply and waste management, energy: electricity, gas, water, communications
- Infrastructure – transport: airports, highways
- Human resources: availability of personnel (metalworking specialists, production and development engineers), work schedules, knowledge of English
- Economic area: competitiveness, access to regional capital, etc.
- Attractiveness: international schools, kindergartens, shopping facilities, recreation
- Costs: salary costs for engineers and specialists; wage growth; land values (cost of building site); prices for gas, water, and electricity; real estate taxes, etc.
- Incentives: support for investment from government

R7: Execute a roleplaying scenario based on the following situation: A politician in Rzeszów is demanding that local wages be raised to the level of wages in Munich. A representative of the companies in the region is offering a moderate wage raise of 5 % per year. Divide into two groups, one for each position. Gather arguments as a group, then choose a representative to argue your group's position. Also, choose one student to moderate.

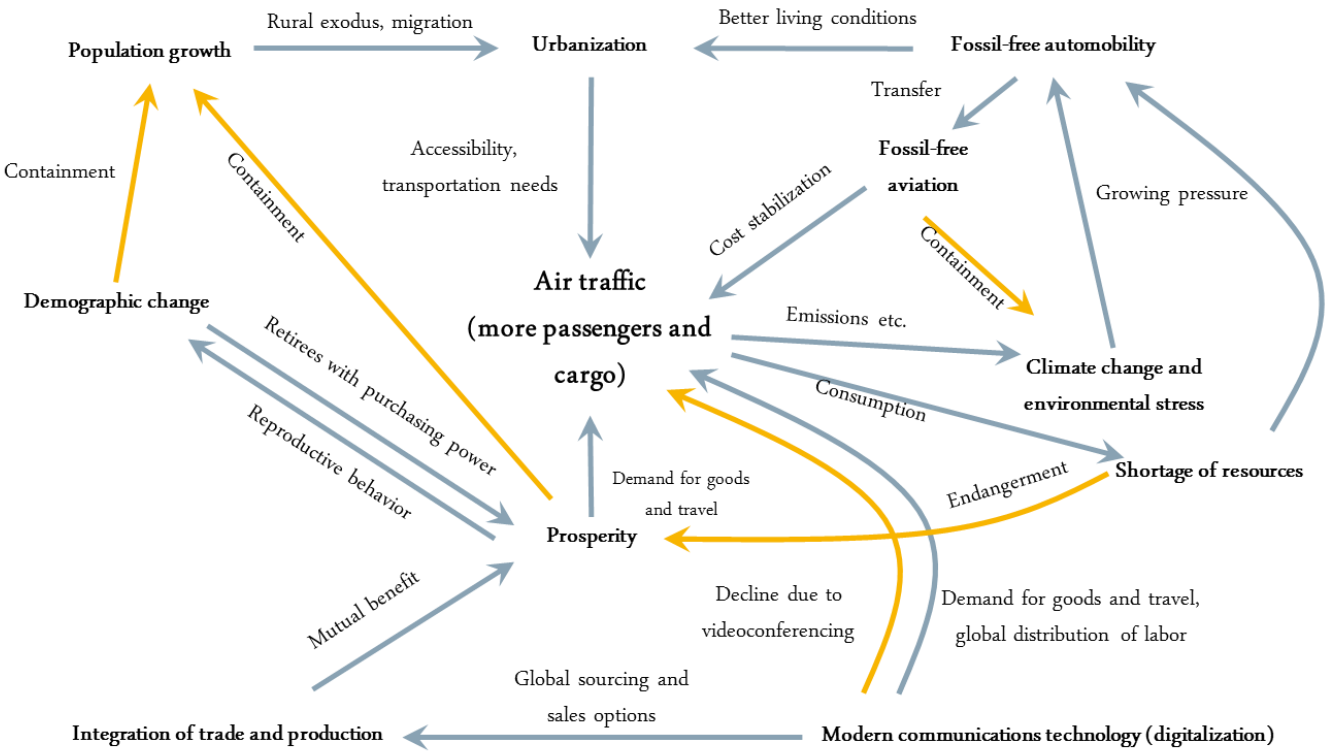
Roleplaying scenario:

- Politician's talking points:
    - Harmonization process in the EU; equal pay for equal work.
    - Workers should share in the value they create.
- Company representative's talking points:
    - Value creation is possible only because wages are lower than in Western Europe.
    - Wages will rise 5 % annually, so the desired adjustment will come about over the medium term.
    - Wages are adjusted to the local cost of living.
    - Wages are above average in comparison to those paid by other industrial companies in the area.
    - Widening the wage gap between MTU and other local industrial companies might disturb the social peace. The cost of living would rise, and domestic companies could no longer afford to pay their workers a living wage.

8 Megatrends as Driving Forces of Aviation

Teaching materials: pgs. 36-37

R1: Draw a diagram showing the influence of megatrends (F1) on air traffic.



R2: Why is China important for MTU? Explain.

- Sales market for MRO services
- Low-cost procurement market for unfinished parts and labor
- Sales market for engines
- Strategic market for future partnerships

R3: Why are foreign airlines not allowed to make direct investments in Indian ones? Justify this policy by reference to a specific development strategy.

Dependency theory: a country isolates itself from international markets to ward off influences that could hinder its development.

R4: Does it make sense that taxes on kerosene in India should be so high? Discuss.

- Pros: source of income for the government, which has had difficulty collecting taxes from other sectors; most airline passengers are wealthy; impeding the growth of air traffic benefits the environment
- Cons: hinders economic development and foreign investment; creates an obstacle for Indians and foreigners wanting to travel

R5: How plausible are the plans for the "World Central International Airport"? Give reasons for an optimistic and reasons for a pessimistic view.

- Optimistic: The global economic crisis will be over by the final expansion phase, then the airport's full capacity will be needed. Large numbers of Chinese and Indian tourists will begin arriving in the Emirates around 2025. The airport fulfills the need for a major hub between China, India, and Africa, connecting these growth regions with each other and with the economic power of Europe. The current Dubai International Airport cannot be expanded any further.
- Pessimistic: The project is too big. Airlines have shown little interest so far. A stopover between surrounding regions may not be necessary.

9 The Demographic Shift

Teaching materials: pg. 38

R1: Interpret the age structure at MTU (F1) with the aid of the demographic transition model. What trend can the company expect to see in the future?

- Younger age groups are underrepresented. The majority of employees at MTU are middle-aged.
- Average age at the company will likely continue to rise.

R2: What challenges is MTU facing as result of the demographic shift, and how do its human resources policies (F2) propose to solve them? Explain.

- Protecting key competencies: MTU's staff is mostly veterans – employees who will soon retire and leave the company, taking their experience with them. The solution is a well-organized knowledge transfer system. This should allow MTU to hold on to its know-how – and its leading position in aero engine technology.
- Attracting and retaining employees: MTU needs suitable recruits to replace its outgoing veterans, but the pool it has to draw from is limited due to demographic reasons. MTU also stands in competition with other employers. The company has not hired many women, female engineering recruits being scarce.
- Work organization and schedules: To hold on to its qualified workers, MTU offers them accommodating work schedules, including part-time options and sabbaticals.
- Physical productivity: As employees get older, they miss work more frequently for health reasons. Thus, as the average age at a company increases, so will the absence rate. MTU has initiated a number of health-promotion measures to help its employees remain in good health and even allow them to extend their careers.