Troubled example:
The trans-Alaska pipeline system: Planning, Design and Construction (1968-1977)

1. Background

- 1968, the Atlantic Richfield company (ARCO) announced that its well had encountered a substantial gas flow.
- It became clear it was the largest oil field ever discovered in U.S.
- It is a priority for development to the production stage.
- A major transportation system would have to be constructed before any oil could be sent to the market.

- The system finally chosen was a pipeline: an 1287km link from the arctic coast to the ice-free port of Valdez on the Gulf of Alaska.
- In summary, the project consists of 3 major components: the pipeline, which would cross 3 mountain ranges, the pump stations and the marine terminal.
- State and federal relationships and Alaska construction cycle are difficult.

- Before statehood, all significant legal power of Alaska was held by the federal government.
- It retained the title to almost all of the land in Alaska.

- For the proposed pipeline, these power relationships had 2 implications:

(1) The federal government would exert a major influence in authorizing pipeline construction and in establishing rules governing design, construction practices, and hiring

(2) The state government would also exert authority and control over project.

Conflict between the two sources.

- In October 1968, ARCO, Humble, and British Petroleum formed Trans-Alaska Pipeline System (TAPA) as an unincorporated joint venture.
- The parent companies exerted control.

- The concept of 48-inch (122cm) diameter and 1287km pipeline
- Initial capacity would be 500,000 barrels (1barrel=159 L) per day, and finally 2 million per day.
- The project was delayed 4 years because of environmental opposition, debate, legal actions and Congressional action.

- The original plan had to be modified from cheaper one to more expensive one.
- Increasing tighter stipulations by the Interior Department further restricted Alyeska’s freedom of choice in design construction practices.

- (Alyeska was the name to the pipeline corporation (consortium of oil companies).

2. The environment

- The trans-Alaska Pipeline System (TAPS) transverses the flat North slope to enter the Brooks Range, it climbs 4739 feet (1445m) from sea level to crest Atigun Pass. It then descends to pass Yukon River. Then it passes through Alaska Range at 3430 feet (1045m), then descend and climb again to top Thompson Pass at 2812 feet (857m). Then it downs to Keystone Canyon and the terminal at Valdez. (Fig.5.1)

2.1 Physical Environment

- The state of Alaska includes 1.52 million km2. located in semi-polar region, 83% of it lying north of the 60th parallel and 27% north of the Arctic circle.
- The region north of the Brooks Range has a temperature range from 32 to -51 degree, with a mean annual temperature -12 to -7 degree. This area is referred to as “arctic desert”.

- The interior area south of Brooks Range and north of Alaska Range has greater temperature extremes (38 to -57) and greater precipitation. The massive Yukon river winds its way through this region from its origin from Canada to the Bering Sea.
- (Fairbanks, the second largest city)

- The area south of Alaska Range represents a transition to a maritime climate along the gulf of Alaska’s shoreline. All terminal sites that received serious considerations from TAPS were located in this maritime climate.
- Anchorage is located in this transition zone.

- The state consists of the 16 tallest mountains in US, more than 120 million acres (492,000km2), 45,100km2 glaciers, 10,000 streams and rivers. Alaska has over 75,639km of tidal ocean shorelines.
- Attracted by the scenery, camping, fishing and hunting, visitors to Alaska enjoy the opportunity to experience the wilderness.
- Many moved to Alaska because of its wilderness character.

- Alaska contains a number of minerals of national interest and energy related resources including oil and gas.
- Alaska has been estimated to have great agricultural potential, even though the infrastructure is not present and agricultural activities are of miner importance.

- 2.2 Wildlife
- 2.3 Valdez and Prince William Sound

3. Phase 2: planning, appraisal and design

- 3.1 Identification and Formation
- This has been covered in “Background”.

3.2 Preliminary Design: FS

- The preliminary route selection was based on a combination of soil borings, soil temperature readings, air temperature data, geographical studies, and aerial photographic interpretations.
- A right-of –way 100 feet (10.29m) in width was recommended for construction for purposes for pipeline excavation and haul road construction.

A formal application by TAPS - June 6th 1969

- 11 pumping stations: each 360x480m
- Two air strips: 60x1500m

- One of the prime considerations was an in-depth analysis of soil conditions to insure a pipeline location providing maximum physical stability and minimum disturbance of natural environment.
- Numeral special studies will establish procedures to be used to meet all requirements of minimum changes to the terrain.

In summary : TAPS proposal

- 122cm diameter hot-oil pipeline
- Buried 90% of its 1287km length
- Initial capacity: 500,000barels(795m3)/day
- 2 million barrels(3180m3/day)/day
- 1032 km would be across the federal land.
- Completion was expected sometime in 1972.
- Haul road about 644 km.
- The TAPS owners expect permits would be granted in July 1969.
- TAPS had already made a substantial financial comittement.

Supporters

- The oil industry which had a resource
- The State of Alaska :substantial economic benefits
- Local state businesses and governments
- Economically and defense-oriented federal government

Opponents

- The environmentalists
- Federal agencies charged with preserving environmental quality
- Some members of Congress, who either supports environmentalists or who preferred to have the oil diverted to the interior US.
- The indigenous Alaskans

The alternatives

- The TAPS proposal of a combined system of pipeline and tankers
- A longer tanker route directly from Prudhoe to the west coast
- A sea route from Prudhoe to the northeast
- A rail road through Canada to the midwest
- A trans Canada pipeline to the midwest

- Additional environmental FS, debates and resulted when the National Environmental Policy Act of 1969 (NEPA) was approved on January 1,1970.
- NEPA declared a national policy of encouraging productive and enjoyable harmony between man and his environment by promoting efforts to prevent or eliminate damage to the environment.

3.3 Pipeline System Design

- To ensure that TAPS did comply with the new standards of environmental integrity and to ensure that the project could cope with the arctic environment, technical solutions representing new pipeline technology had to be developed.

The technical problems to be overcome

- Insulating the permafrost from the hot oil
- Providing enough flexibility so that the pipeline would not settle or sink as the hot oil started to move.
- Providing a design to a severe earthquake
- Providing a rupture detection system not to make oil spilled
- And so on

The solutions

- Where the line is buried in permafrost, the line is insulated and permafrost is refrigerated by pumping cold brine through buried pipes.
- Building the pipe in a zigzag configuration
- All tanks are surrounded by dikes to contain any spills in case of rupture.
- The terminal facility is designed to withstand an earthquake registering M8.5.
- And so on.

In summary, TAPS called for construction ---

(1) A haul road

(2) The pipeline itself

(3) Pumping stations

(4) The Valdez terminal

(there was another problems to refine Alaskan oil and require the interior pipeline system.)

5.4 Phase 2: Selection, Approval and Activation

4.1 Selection

- The decision of selection is very complicated. (So many owners and decision makers)
- The actions of the Interior department were designed to issue a permit (TAPS concept) as soon as possible, if the concept ensure a certain amount of protection for both the environment and the claims of indigenous Alaskans.
- The department also started to study a 12 mile wide transportation corridor along the proposed route.

- Despite, officially authorized construction in 1969 was relatively minor.
- Preliminary work on ground clearing at the Valdez terminal site was authorized by the Forest Service. A short segment of the haul road was authorized by the Interior Department.

Tactics by the environmentalists

- Media, lobbying, etc.
- The most effective delaying tactics turned out to be the court suit.
- In March and April 1970, several suits were filed in the federal courts by both indigenous Alaskan groups and environmental organization.

The 3 basic sources of legal ground

- A pipeline right-of-way: 8m, 30m or more
- The Alaska land freeze brought about by the claims of indigenous residents.
- NEPA became the primarily basis for legal challenges to TAPS plan.

- The original design plan had to be modified from one in which about 95% of the pipeline would be buried to one in which only half would be buried.
- Increasingly tighter stipulations proposed by the Interior Department further restricted Alyeska’s freedom.
- (TAPS was reorganized as Alyeska.)
- In 1970, Alyeska estimating $3 billion.

Alternatives

- TAPS proposal (original)
- Trans-Canada alternative
- Complete tanker system
- Complete railroad system

- Because each had to make economic and other assumptions in the analysis, the results were often contradictory and open to criticism.

4.2 Environmental Concerns

- The oil companies were surprised that the permits were not granted rapidly.
- They were very optimistic, partly because that the damage would be limited to a very tiny proportion (0.01% of Alaska).
- TAPS, however, had underestimated the complexity of the situation.
- The TAPS proposal would be attacked as bad design, as environmentally undesirable.
- The resulting debate would take 4 years.

In the view of environmentalists : 4 distinct scenarios

(1) Poor construction practices and carelessness could pollute and scar the environment.

(2) The line would be inadequately supported and subject to rupture.

(3) A severe earthquake would rupture the line and tanks.

(4) Tankers would make collision and spill oils.

- Despite the criticism from environmentalists, economists, and others concerned with both oil and impact, the oil companies held to their first choice.

4.3 Approval

- Indications of energy crisis were apparent to many in Congress.
- The Trans-Alaska Pipeline Authorization Act of 1973 passed in both houses of Congress.
- The estimated cost of the pipeline climbed up to $4 billion.
- (Also, provided public agency involvement.)

4.4 Activation

- The traditional construction cycle in Alaska begins in winter, when temperature drops to -59. In this cold, the Arctic tundra is frozen and its delicate surface is less likely to be damaged by the equipment.
- During winter, heavy equipment and materials are moved to construction sites across temporary snow roads and ice bridges.

The next step begins in early spring.

- Once begun in spring, work often continues either until the project is completed or the weather cools in the fall. Most construction not completed by late September or early October is abandoned until the following spring; winter construction normally too costly.

The 8 firms comprises “committee”

- Agreement on project policy by owner was a common prerequisite for major construction decisions and actions.
- Throughout the 1969-73 debate, Alyeska was in its promises to provide blue ribbon environmental protection.
- In that paper, the pipeline company describes its ambitious environmental plans.

Among the claims that were never implemented

- Tankers would be no larger than 150,000 dead weight tons
- The pipeline would be welded and inspected to national welding standards.
- The entire pipeline could cut be shut down in 5 minutes.
- The oil spill contingency plan would be completed 1 year before start-up.

Organized chaos

- In 1969 the owners formed the Trans-Alaska Pipeline System (TAPS) with personnel borrowed from the parent companies.
- They formed a committee system with an 8 person Owners Management Committee and a 3-person Project Management Committee.
- The duplicative committee system resulted in “Organized chaos”.

Alyeska and TAPS

- In an effort to create a more efficient arrangement, the owners incorporated Alyeska in 1970. The name “TAPS” stayed with the pipeline, so did the organization problems.
- To spend money to plan and build the pipeline, Alyeska still had to obtain approvals from the various owner committees.

Conflicts

- Alyeska: Bechel,
- The Owners: Arctic Constructors,
- Then Bechtel and Fluor
- The engineering and construction process Fluor supervised was chaotic.
- By May 1973 – five months after Fluor began work- cost was increased from $7 million to $17million.

Design work lagged behind schedule

- 1973-1976
- Fluor required the extra time to complete terminal engineering because of “ changes brought about by the terminal tank farm redesign, reassessment of electrical work turned over by Alyeska which Fluor claimed was incomplete, and some omissions in Fluor’s base estimate.

5. Phase3: Operation, control, and handover

- 5.1 Implementation
- 5.1.1 Brief overview
- The builders of the Trans-Alaska pipeline tried to follow Alaska’s traditional construction cycle.
- December 1973: Snow roads and ice bridges were built.
- January and April 1974: Heavier equipment and materials were moved.

- April 29: Official construction commenced. The haul road was completed during the first construction season.
- 1975 and 76: 1287km of pipeline, the pump stations, and the marine terminal in Valdez were completed.
- June 20,1977: Oil was introduced into the pipeline at Prudhoe Bay.

5.1.2 Construction of Haul Road

- 576 kilometers of highly compacted and graveled surface road were constructed.
- More than 5 years were required to design, gain approval for, and complete a road that required only 9 months.
- 5 construction contractors were assisted by 7 local contractors and regulated at least 14vgovernment agencies.

- Employees working on the haul land had to learn hoe to use the special arctic equipment, to understand the constantly changing land forms of Alaska (from arctic desert to the highest mountains in North America).
- Coordinating construction was complicated. Because Alyeska’s corporate headquarters were in Anchorage, but actual haul road construction headquarters were 571km north in Fairbanks.
- Further complicated by arctic weather and atmosphic conditions.

5.1.3 Pipeline Construction

- The scope of the Trans-Alaska pipeline project is massive.
- It is the largest construction project undertaken by contemporary private industry. Nearly 15,000 workers were assigned to pipe installation and related tasks during the summer peak.
- Usually, pipe-laying activities forged ahead of other parts, because not so much difficulties.

3 sections were part of the last construction

- Atigun Pass: Glacial soils in the original burial route and avalanche danger
- Keystone Canyon: The high way prevented the laying of pipe on the canyon floor
- Thompson Pass: Crews were faced with several miles with 45 degree slopes.

5.1.4 Construction of the Marine Terminal and Pump Station

- Responsibility was contracted to the Fluor on December 21, 1972.
- Fluor’s management activities are distinguished from those of the rest of the pipeline project.
- First, since much of Fluor’s work was performed indoors, and crews worked year round, workforce levels tended to remain relatively small.

- Flour’s management , however, did find its task more complicated.
- Welding required extra ability because of the special low temperature mettallurgy.
- Unusual stress, snow load, permafrost, earthquake safety requirement, and government monitoring stipulations combines to make the Alaska terminal facility and pump station unique.

5.2 Supervision and Control

- Alyeska was responsible for overall project management, with Bechtel and Fluor as CMCs. Alyeska reviewed CMCs’ proposal and recommended to the owners which firms should be awarded contracts.
- Alyeska’s tasks included the design of the pipeline. The engineering team revised this original design, so that at completion 52% of the pipeline was buried.

- Alyeska’s building task was to supervise the firms doing the actual construction.
- As project manager, it intended to audit and ensure fulfillment of contractual obligations by the CMCs.
- Alyeska should do preparation, revision, and control of the project budget.
- Budget escalated from $900million initially to $4.5billion in 1974, $8billion in 1977 and growing.

- Government agencies required to Alyeska to make reports regarding erosion control, construction related oil spillage, sewage, fair employment commitment and damage to wildlife.

The CMC duties

- Bechtel : haul road and pipeline
- Fluor : the pump station and marine terminal
- Each CMC was given decision making latitude within the boundaries of its specific tasks.

The relation between CMCs and other members

- Differed
- Fluor worked in conjunction with Alyeska to design the pump stations and marine terminal.
- Much of the engineering design directly supervised by Fluor, the transfer from design to finished product was much simpler. Communication links was also simpler because its task was centrally located.

- Bechtel did not work in conjunction with Alyeska to design.
- Bechtel began its duties without intimate familiarity with the engineering aspects of its tasks. Bechtel’s communication links were relatively complex because its 2 tasks were spread out over 1287km.
- Bechtel’s ability to supervise was somewhat reduced.

- Alyeska’s management role was modified greatly by top-level management decisions.
- As already suggested, the opinions of the owners, their ad hoc subcommittees, and Alyeska differed.
- Alyeska consisted of employees on loan from the owner companies.
- No particular philosophy prevailed.

In summary

- Lack of coordination and cooperation plagued by 4 tiered management structure established by owner companies:

(1) The owners' committee

(2) Alyeska

(3) Bechtel and Fluor

(4) ECs

monitoring

- The federal authorizing officer, the state pipeline officer and the joint fish and wildlife advisory team did most of the monitoring.
- They had the power to halt the project if construction activities violated the law.

5.3 Completion and handover

- The final measure was the call for "oil in" at Prudhoe Bay in 1977.
- The oil was hot and the pipeline was cold. The pipe line was heated and while the oil cooled antil the 2 reached the same temperature. The oil reached at pipeline 71 degree, the pipeline was -7 degree.
- The conventional method to fill water in a pipeline could not be used. Because the water would freeze.

- The Alaska pipeline used nitrogen, which is an inert gas that cannot support combustion. For several weeks, the crews continued to check for oil leaks and weight distortion.
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- Nonetheless, the oil spills are almost inevitable. The pipeline design included highly sensitive oil leak detector devices.

- For the most part, the pipeline start-up process was relatively smooth.
- Alyeska found a huge amounts of surplus construction equipment that had to be sold after the completion of the project.

- When construction was completed during the summer of 1977, Alyeska was demobilized.
- Alyeska’s construction company was dissolved and replaced by its operating company.
- The responsibility of the new company is to operate and maintain the pipeline.

6. Phase 4: Evaluation and Refinement

- 6.1 Evaluation of Phases 1 to 3
- Results and problems were analyzed in the framework of the integrated planning and quality management system (IPQMS).

6.1.1 Phase 1

- This formative or preconstruction phase was plagued by many legal challenges which delayed the start of construction.
- The basic problem inherent in phase 1 and subsequent phases was one of mismanagement and indifference to project cost.
- The lack of understanding the need for single project management team over the entire project cycle was the great problem.

Of the particular concerns in FS

(1) Inadequate geotechnical studies for the later design and construction

(2) Lack of understanding of workers productivity, material procurement, and communication problems in the arctic environment.

Inadequate design data were prepared for the all components of TAPS. The need to constantly revise design contributed to the cost overrun.

6.1.2 Phase 2

- One of the crucial problems of the project was that its organizational hierarchy and management structure were poorly conceived.
- Because of the confusing lines of management authority, the owners and Alyeska failed to establish

(1) A project cost estimate plan and related control systems for implementation/expenditure

(2) Viable contractor incentive plans for work in a difficult environment

- In addition, the management of TAPS failed to develop systems and procedures to ensure that construction equipment , material, and spare parts were purchased, delivered and inventories in a cost effective manner.
- ECs desperately sought to requisition spare parts which were already in their own warehouses.

- Equally serious was the failure to provide sufficient labor facility labor camp facilities, a cost effective food catering service, and an adequate communications system.
- In sum, making policy decisions was clearly influenced by self-interest on the part of the owners, compounded by lack of understanding of the project’s needs.

6.1.3 Phase 3

- There were serious disputes among the owners, Alyeska and Bechtel concerning the appropriate scheduling of design and manpower, as well as the basic contracting strategy with the ECs.
- For example, Bechtel recommended negotiating ECs at the earliest possible time to allow their involvement in planning.
- When this strategy was rejected, Bechtel correctly estimated the resulting loss.

- The duplicative management system structure developed by the owners led not only to excessive administrative costs but also to paralysis of decision making system.
- Another serious problem was that of workers frequently idle at the job site. Most of the workers were willing to work but lacked “ adequate direction and support” from a disorganized project management.

The impact of late and inadequate design work

- The results of these deficiencies included;

(1) Numerous and costly delays as men and equipment

(2) Problems with efficient work rescheduling as contractors tried to build around those areas for which lacked sufficient engineering

(3) In some cases, work that had to be redone because of inadequate engineering studies.

6.2 Refinement

- A special study of construction costs was mandated by the Alaska Pipeline Commission.
- The resulting report concluded that over $1.5 billion were lost to waste, fraud and mismanagement.

7. Lessons learned

- Most of the problems could have been avoided if the owners and their project management group had recognized the importance of teamwork.
- The second lesson is the need for a detailed checklist of questions to the prepared by the owners and their representative preparatory to commencing the FS.

- The third lesson is the overdue need for a data base for planning, designing, constructing a variety of public works and private sector projects in different environment.
- A fourth lesson is the need fpr detailed FS.
- Related to the above lessons are lessons regarding the need for project responsibility and accountability.