

2. *Component development*, that is, the more or less independent development of items of military hardware which are not themselves "weapon systems" or "major equipment," but parts or sub-systems of such major equipment. The distinction between systems and sub-systems is, of course, arbitrary. The important thing is that the Services can and do spend money productively developing engines for aircraft, guidance systems for missiles, gyroscopes for guidance systems, communication systems for armored vehicles, gear for landing aircraft on carriers, and so on, without knowing precisely the type or model of the major equipment of which the component will be a part.

3. In *exploratory development, or applied research* the objective is advancing the state of the technological art rather than obtaining immediately operational hardware. Someone has had a promising idea for a new type of vacuum tube or a new fuel or a new design to reduce drag in an aircraft wing. The idea may have emerged from paper research or may simply have been someone's inspiration. Whatever its origin it requires some sort of testing or verifying before it can be accepted as valid and incorporated in the state of the art. This may involve a laboratory experiment, a wind tunnel test, or the construction of a working model, depending upon the nature of the idea. Test models are typically very much cheaper than operational models, although there are some exceptions.

4. *Basic research* is the deliberate search for knowledge. The military Services, AEC, NASA, and so on, support a good deal of basic research in areas of special interest to them, such as aerodynamics, atomic physics, and some branches of mathematics. Basic research is typically the cheapest type of research and development if we think of something like "cost per idea explored." It frequently requires no equipment except paper, and with some exceptions (betatrons, for example) even the scientific laboratories and computing equipment that are needed cost less than a single operational prototype of a new aircraft or missile.

We estimate that, using generally accepted definitions, military research and development in the late 1950's was costing about \$6 billions per annum. This estimate is both arbitrary (the boundary between "development" and "production" is hard to draw)<sup>4</sup> and misleading, since by far the largest part of this total is at the weapon system end of the research and development spectrum and includes large costs of fabricating operational prototypes. Expenditure really devoted to advancing science and technology in areas of special military interest is much less — perhaps \$1 to \$2 billions. This would include basic research (on the order of

<sup>4</sup> For example, when the Air Force (or Navy) contracts for a new model of aircraft, making the first "prototype" batch is regarded as development. But when the Navy contracts for a new model of submarine, constructing the very first is regarded as production.