Integration

Kevin Cameron

It's possible for the whole to be less than the sum of its parts. My favorite example comes from the jet-engine business, but the concept is applicable to everything from marriage to racing teams to politics. Here it is.

Back around 1970, Rolls-Royce was developing the big RB-211 engine for the Lockheed L-1011 aircraft, but this advanced engine persistently failed to meet design goals. Business failure was imminent. In desperation, the company called one of its finest engineering managers, Stanley Hooker, out of retirement. What he found was an engine whose individual systems were excellent. The difficulty was that the output of one stage was not at all what the next stage required - from one end of the engine to the other. Each stage had been developed by a separate engineering group, charged with producing the finest possible performance for its "slice" of the engine. Each department had pursued its own goals behind closed doors, and with little reference to any other department.

Hooker, originally hired by the company in 1938 to solve supercharger design problems, was an experienced man with an experienced man's overview of design. He instantly saw that although the efficiency of the engine's systems was individually very good, their integration was terrible. He therefore decided upon the various tweaks it would take to at least roughly match each stage to the next, and he required each department to accept his modifications.

There was protest. Everyone howled that Hooker's changes would ruin their stage efficiencies. The result? Individual stage efficiencies did fall, but the thrust of the engine as a whole rose by 6000 pounds! This was no miracle. Just the reasonable result of changing the standard of what constitutes success. Before Hooker, success was measured in stage efficiency; once he was placed in charge, it became overall engine performance. What Hooker did was to integrate all the good work of the separate departments.

An inkling of similar attitudes in our own industry was related to me by the former editor of *Cycle* magazine, Cook Neilson. He was approached by an engineer of one of the major motorcycle makers, soliciting ideas as to what might help the handling of one of the company's less stable models. Cook replied that he thought the machine's frame was too flexible ever to handle well.

"Oh," the engineer replied, shaking his head, "Frame is not my problem. It is frame department problem. My department is handling department."

How's that for separating the inseparable? Any time you work with a complex system - and motorcycles qualify for the term - there exists this temptation to analyze the complexity into separate parts, and to work on the parts as if their functions were, indeed, separate. Usually they are not.

Another view of design integration comes from an electronics engineer friend of mine, who remarks that, "Just as the impurities in a crystalline substance accumulate at the grain boundaries, so problems in design tend to appear at the interfaces between disciplines." Why? Because we are uncomfortable with what we don't understand, and so avoid it. Let somebody else with more specific knowledge take care of that.

What is needed is the courage to operate with less than perfect knowledge. Complete knowledge is an illusion in any case, generated by the existence of such things as job titles, engineering handbooks and college courses. We are supposed to believe that science discovers nature's rules, while engineering finds safe, workable ways to apply them. Wouldn't it be nice if life could be so simple. But, in fact, we all confront the same huge universe, so our equally huge ignorance forces us all to be scientists.

The same is true of narrow specialties; we can't, for instance, chase all the unknowns out of connecting-rod design, reducing it to a simple matter of canning a few standard formulas into a $5000 piece of computer software, entering the data, then hitting "Return." That's how people design yesterday's parts today, for tomorrow. There's no innovation in the handbook. There has to be a Stanley Hooker in the affair somewhere, with confidence to broadly sketch together our partial knowledge into a new and successful synthesis.

Another such confident engineer was the quietly influential but today little-known S. D. Heron. A mechanical engineer in Britain's early aviation development, he soon found thermodynamics standing in the way of design progress. He therefore tackled thermo, in the process learning how to pull heat out of engine cylinders so they could survive at ever-increasing power.

When later it was fuel chemistry that impeded engine development, Heron again plunged in where others feared to show their ignorance. He became a successful referee in the difficult collaboration of the fuel industry and engine manufacturers in those years (1923-41) when the integration of fuels and engine design finally found a way past the vexing problem of detonation. Heron wanted to solve problems more than he wanted to remain safely nestled inside the walls of mechanical engineering.

Of course, the separation of knowledge into specialties is completely artificial, but has been practiced as a means of making teaching manageable. How often does an engineering school offer courses with names like, "Fundamentals of the Universe in all its Glorious Complexity?" Real-world problems have the annoying habit of failing to respect the well-kept lawns that separate the math, chemistry, physics and mechanical engineering buildings at universities.

Human curiosity, at its best, is equally disrespectful.

[*Cycle World Magazine,* August 1993] *(Special thanks to car377 whose memory of things motorcyclic is truly encyclopedic.*)