2.BRAIN-MACHINE INTERFACE Robert Asher, Sandia National Laboratories June 2002,Arlington, Virginia Increasingly, the human is being asked to take in multisensory inputs, to make near-instantaneous decisions on these inputs, and to apply control forces to multitask and control machines of various sorts. The multitasking, multisensor environment stresses the human, yet, more and more s/he being asked to operate in such an environment. As an example, the visionary project on uninhabited combat vehicles discusses an increased workload in piloting combat vehicles. DARPA has a brain-machine interface program about to start. This program has as its goal human ability to control complex entities by sending control actions without the delay for muscle activation. The major application for this program is control of aircraft. The intent is to take brain signals and use them in a control strategy and then to impart feedback signals back into the brain. The DARPA program could be extended to include a broader range of potential impact by including the possibility of other applications: learning and training, automobile control, air traffic control, decision-making, remote sensing of stress, and entertainment. Learning and training might be implemented as information coded into brain signals and then input into the person. Air traffic control in increasingly busy skies can use such capability: the controller has multiple inputs from multiple aircraft. These can be input into his brain in a 3-D aspect and an alertness signal used to “wake him up” when his attention drifts beyond acceptable limits. Not only intellectual data might be passed from one person to another without speaking, but also emotional and volitional information. Decisionmaking may become more precise as emotional, fatigue, and other cognitive states can be appraised prior to making a critical decision. The potential impact on automobile safety is great. The driver can have quicker control of his automobile (Fig. E.15), allowing for safer driving while reducing the car-to- car spacing on congested highways. This would help alleviate highway congestion and the need for more highways. Furthermore, it would allow for safer driving as driver attention can be measured and the driver “alerted” or told in some manner to pay attention to his or her driving when attention wanders beyond safe margins. It can allow for detection of driver impairment so that the vehicle may be made either not to start or to call emergency. Direct connection into the brain could yield a revolution in entertainment, as people may be “immersed,” MATRIX-style, into the midst of a movie or educational show. Can you imagine the impact of being immersed in a fully 3-D audio-visual simulation of the battle of Gettysburg? 8 Hands-off control of an automobile through a device for reading and implanting brain waves. Role of Converging Technologies Nano. The brain-machine interface effort will require nanotechnologies in order to make the required experimental measurements and to implement the devices for both receiving brain electromagnetic signals and transmitting signals back into the brain. Bio. This is a highly biological, neuroscience effort, which requires detailed understanding and measurements of the brain’s electromagnetic activity. It requires a significant measurement protocol. Cogno. This effort by its very nature will directly affect the cognitive aspects of the individual by externally applied electromagnetic fields by implanting information for the individual. Thus, this effort can lead to increased learning and other cognitive results. Transforming Strategy to Reach the Vision To achieve these goals, enter a partnership with DARPA to fund additional technologies and applications that would enhance the brain-machine interface effort. Work should be focused on the goals of using the technologies for cognitional aspects, understanding memory, and learning brain function to be able to design devices to increase their capabilities. Estimated Implications This effort would yield a technological revolution, in applications from computers to entertainment. It would give the United States a global competitive advantage while yielding solutions to specific domestic problems such as air traffic control and highway safety in increasingly crowded environments. It will revolutionize education. This effort will yield devices that may be applied to a number of activities and be sufficiently small as to be wearable in a car or at home. 9